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Environmental Protection Agency
Washington, D. C.

July 1973

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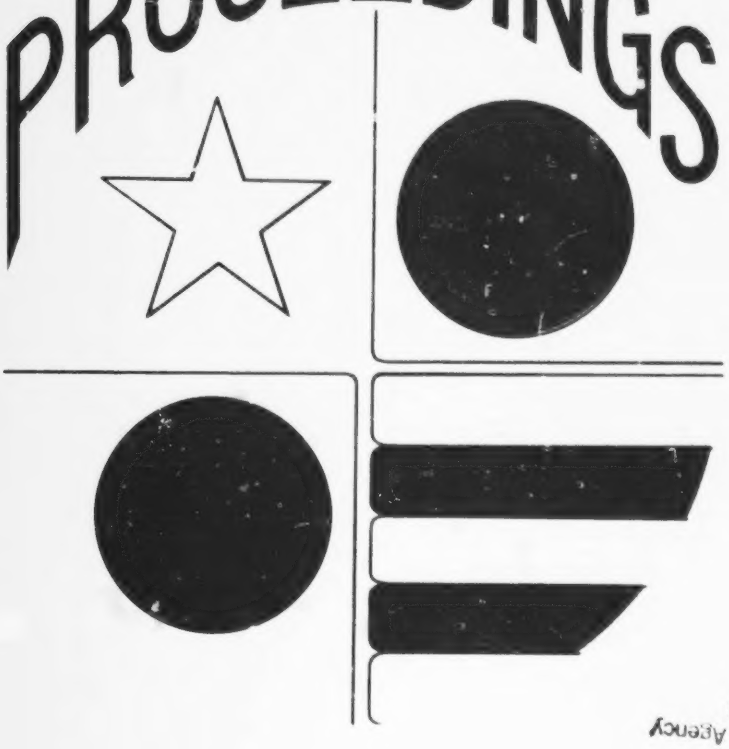

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U. S. - JAPAN CONFERENCE
ON
SEWAGE TREATMENT TECHNOLOGY

DECEMBER 1-6, 1972

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SECOND

U.S. - JAPAN
CONFERENCE ON
SEWAGE TREATMENT TECHNOLOGY

December 1–6,1972

OFFICE OF INTERNATIONAL AFFAIRS
OFFICE OF AIR AND WATER PROGRAMS
OFFICE OF RESEARCH AND DEVELOPMENT
U.S.ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON,DC. 20460 . JULY 1973

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FOREWORD

In understanding life systems, controlling environmental degradation, and managing a planet for the well-being of all its peoples, we are all beginners. But in the past decade the United States and Japan have taken some important first steps in these tasks.

In these early efforts we have learned that in facing similar difficult problems--of concentrated populations, of resource demanding advanced economies, and of polluting technologies--solutions can be found through intelligence, good will, and mutual cooperation. We have learned too, that meaningful cooperation does not and cannot occur in an instant, but rather must evolve over time through mutual patience and persistent effort.

The proceedings of the Second U.S.-Japan Conference on Sewage Treatment Technology presented here thus represent not an isolated instance of cooperation, but an integral part of an ongoing program of cooperation begun in 1964 by the U.S.-Japan Cooperative Program on Natural Resources and expanded by the Ministerial Agreement of 1971. These proceedings represent also the proof that nations can work together for mutual good when they commit themselves to the task.

As the United States and Japan look to the future, it is my hope and conviction that the next decade of environmental cooperation between our two countries will be even more fruitful than the first.

William D. Ruckelshaus

William D. Ruckelshaus
Administrator

Washington, D.C.
April 13, 1973

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ITINERARY OF JAPANESE TEAM IN THE UNITED STATES - 1972

November 26	Arrived in Los Angeles, California
November 27-28	Visited Los Angeles County Sanitation District's No. 2 offices, treatment plants and research facilities Host: Mr. John D. Parkhurst Chief Engineer & General Manager
November 29	Visited Advanced Waste Treatment Plant at Lake Tahoe, California Host: Mr. Russell Culp General Manager South Lake Tahoe Utility District
November 30	Visited EPA Region IX Offices in San Francisco, California Host: Mr. Paul DeFalco, Jr. Regional Administrator
December 1-2	Joint Conference on Advanced Waste Treatment National Environmental Research Center - EPA Robert A. Taft Laboratory Cincinnati, Ohio Hosts: Dr. Andrew W. Breidenbach, Director Mr. Francis M. Middleton, Deputy Director
December 3-7	Joint Conference on Air and Water Programs Environmental Protection Agency Washington, D.C. Hosts: Mr. Robert L. Sansom Assistant Administrator for Air and Water Programs Mr. Ralph E. Palange Engineering Advisor, Office of Deputy Assistant Administrator for Water Programs

December 8	Visit to National Environmental Research Center - EPA Corvallis, Oregon for discussions on eutrophication research Host: Dr. Alfred F. Bartsch Director
December 9	Depart for Tokyo, Japan

Program Coordination EPA - Office of International Activities
Mr. Andrew M. Caraker

SECOND U.S. - JAPAN CONFERENCE ON SEWAGE TREATMENT TECHNOLOGY

Washington, D.C., December 6, 1972

JOINT COMMUNIQUE

1. The Second United States - Japan Conference on Sewage Treatment Technology was held in Cincinnati, Ohio, and Washington, D. C., from December 1 to 6, 1972.

2. The Japanese delegation, headed by Dr. Takeshi Kubo, Director General, Department of Sewerage and Sewage Purification, Ministry of Construction, was composed of five national Government officials and three local government officials.

3. The U. S. delegation, headed by Dr. Robert L. Sansom, Assistant Administrator for Air and Water Programs, Environmental Protection Agency (EPA), consisted of 11 EPA officials and a representative from the Water Pollution Control Federation. Mr. Fitzhugh Green, Associate Administrator for International Activities, EPA, opened the conference in Washington, D.C., and welcomed the visiting delegation. Mr. Frank M. Middleton, Deputy Director, National Environmental Research Center, EPA, organized the conference in Cincinnati, in which discussions were focused on advanced waste treatment.

4. In addition to the conferences, the Japanese delegates visited the Los Angeles County Sanitation District's Pomona Water Renovation Plant, San Jose Creek Water Reclamation Plant and Joint Water Pollution Control Plant, the Los Angeles City Hyperion Waste Treatment Plant, the South Lake Tahoe Water Reclamation Plant, California and EPA Region IX in San Francisco. They will also visit the National Environmental Research Center, EPA, in Corvallis, Oregon.

5. The U.S. - Japan conferences on sewage treatment technology grew out of the Second U.S. - Japan Ministerial Conference on Environmental Pollution held at Washington, D.C., in June, 1971 between Chairman Russell Train of the Council on Environmental Quality and Japanese Minister Sadanori Yamanaka. The First Conference on Sewage Treatment Technology was held at Tokyo in 1971.

6. During the Conference the Japanese delegation presented a series of papers outlining the development of sewage works in the past decade, comprehensive basin planning, progress, plans and financing of sewage works, and establishment of the Japan Sewage Works Corporation. Presentations were also given on establishing water quality standards and countermeasures, combatting industrial waste pollution in Yokohama and sludge disposal in Tokyo, industrial waste treatment technology and the status of Japan's research program on Sewage Treatment Technology.

7. The U.S. side described the mission of EPA's Office of Air and Water Programs waste treatment activities, recent U.S. water legislation, preparation of water regulations and guidelines, use of new technology in wastewater treatment plant design, water quality management planning, design guidelines for municipal wastewater treatment works, operation and maintenance guidelines for municipal wastewater treatment works, guidelines for joint treatment of municipal and industrial wastes and industrial waste guidelines, including metal and metal products, chemicals, textiles and final processing. Mr. R. A. Canham of the Water Pollution Control Federation expressed his organization's viewpoint on EPA regulations and guidelines.

8. Each presentation was followed by vigorous discussions from both sides.

9. The Conference concluded that, in order to maximize the benefits which can be gained through cooperation between the United States and Japan, emphasis should be placed on closer exchange of experts and information between the two countries.

10. To that end the delegations agreed to an exchange of technical personnel between the two countries which would involve on-the-job training of Japanese engineers in U.S. treatment plants and laboratories. Also a U.S. Sewage Treatment Technology Transfer Team will visit Japan in 1973 to conduct a seminar with Japanese engineers and scientists. In addition, the delegations agreed to seek to identify sewage treatment research projects which might be undertaken jointly by U.S. and Japanese experts.

11. The delegations shared the view that these initial actions would lead to other productive cooperation in the field of sewage treatment and that additional means of expanding cooperation would be explored in the coming months.

12. It was proposed by the Japanese side that a third U.S. - Japan Conference should be held in Japan.

US-Japan Conference
on
Sewage Treatment Technology
Paper No. I

STATUS OF RESEARCH PROGRAM ON SEWAGE TREATMENT TECHNOLOGY IN JAPAN

December 1-6, 1972

Ministry of Construction
Japanese Government

I Status of Research Program on Sewage Treatment Technology in Japan

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1. Preface

Studies and researches on sewage treatment technology in Japan are carried out by national research organizations, sewerage departments of local governments, public and private universities, and laboratories of private companies. The results of these studies are usually published on the Journal of Japan Sewage Works Association (JSWA), Journal of Japan Society of Civil Engineers (JSCE) or, other commercial technical magazines, or reported at the JSCE annual symposium, JSCE symposium on sanitary engineering or JSWA annual symposium. Recent years, since water pollution in public body of water has become a nation wide problem and the budget for sewage works in the national and local governments has accordingly increased, studies and researches in this field have been paid considerable attention, resulting in the increase in the number of reports.

The trend in studies, as investigated on the basis of papers submitted to the annual symposiums of JSCE and JSWA, is as shown in Table-1. 1.

Since the activated sludge process is most commonly adopted as secondary treatment in sewage treatment plant in Japan, there is a great number of studies on this subject. On the contrary, there are exceedingly rare cases of studies performed on trickling filter process and other aerobic treatment processes. Recent studies on activated sludge process include those on pure-oxygen aeration process and treatment of supenatant liquor from heat treatment of sewage sludge. As recent trend in the studies on water pollution, studies on food chain and its relationship with pollution, water quality simulation model and the effect of deposited sludge upon water quality are becoming popular. In the field of the study on treatment and disposal of sewage sludge, heat treatment, incineration, and methods of disposal are the major subjects. Papers on studies on tertiary treatment of sewage have rapidly increased recently. However, these studies are mostly basic experiments of various processes, and so far, only few studies are being made on the problems relating with design, construction and maintenance of actual plant such as costs, treatment and disposal of sludge or brine, reuse of coagulant and so on. As for the study on industrial wastes treatment, due to intensification of industrial wastes control, the study on the method of treatment is being accelerated for various industries such as marine products processing factory, petro-chemical industries, and dyeing works. Most of these studies are on the treatment of the wastes in the case when the effluent is discharged into receiving water directly, and few studies are on the pretreatment facilities in the case when the effluent is discharged in to the public sewerage system.

As mentioned above, studies and researches on sewage treatment technology are carried out by many research organizations, and the reference to these all may end only in an all-inclusive statement. Therefore, in this paper, reference is limited only to those being performed solely by the Ministry of Construction, or by it jointly with local governments.

Table 1-1 Number of Submitted Study Papers

Item / Year / Name of Symposium	Japan Sewage Works Association		Japan Society of Civil Engineers	
	1971	1972	1971	1972
Administration	7	7	-	-
Planning	11	8	4	2
Sewage Quality and Quantity	3	2	-	-
Construction	14	11	-	-
Sewage Treatment				
Activated Sludge Process	20	14	8	15
Trickling Filter	1	-	-	1
Other Secondary Process	1	7	-	-
Tertiary Process	7	4	7	9
Measurement and Instrumentation	7	12	-	-
Sludge Treatment and Disposal	23	17	7	5
Radio Isotope Waste Treatment	-	-	8	7
Industrial Waste Treatment	9	13	-	2
Water Pollution	3	6	9	12

2. Studies on Sewage Treatment

2.1 Upgrading of Secondary Treatment

2.1.1 Present Status of Secondary Treatment in Japan

For the first time in 1922 in Japan, sewage treatment was initiated at the Mikawajima Sewage Treatment Plant in Tokyo, and subsequently began at the Atsuta and Horidome treatment plants in Nagoya City. Full-fledged sewage treatment was conducted only in Tokyo, Osaka, Nagoya and four other cities in the prewar days, and their service area was limited to the downtown section.

At present, there are 232 sewage treatment plants, and sewage treatment is served for 21,800,000 people, that is 34.7 percent of the urban population. Of these plants, more than 70 percent have been constructed after 1963. Table 2.1 shows their breakdown. The activated sludge process and its modified processes are used at 71.4 percent of the treatment plants. There are also treatment plants only by plain sendimentation but these are temporally expedient until secondary treatment facilities are established. In the near future, these plants will be replaced by the activated sludge process.

There are a lot of small sewage treatment plants with capability of 10,000 m^3/day or less. Most of them are for the newly established housing areas in the perimeters of existing urban areas. They have been preliminarily established as facilities designed only for these housing areas, as sewerage systems are yet to be covered for existing urban areas.

2.1.2 Fundamental Studies on Activated Sludge Process

The Institute has been carrying on basic studies since 1967 for a further improvement of the quality of effluent from the activated sludge process.
The major studies are as follows:

a) To examine the influence of the change in the incoming load on the treatment process.

b) To examine differences in the treatment characteristics of aeration tanks with different mixing characteristics, and

c) To find an appropriate index for operation of activated sludge process.

The experiment was conducted with an activated sludge process system of the continuous flow type. Initially, the experiment was carried out using actual domestic sewage. But, as it was difficult to adjust input concentration, and other conditions and the Institute is not located to get appropriate sewage in its neighborhood, it was decided to use synthetic sewage.

Several different synthetic sewage which had been proposed previously were tested. But all of them got into trouble of bulking after 1 or 3 months of acclimation.

Then new type had to be developed. The composition of the sewage is shown in Table 2. 2. To compensate for the lack of inorganic matter, $CaCl_2$ is added at a rate of 100 Ca ppm. The results that have so far been secured are summarized in the following:

i) In a load change of 2 to 3 times against the incoming concentration of 200 ppm of BOD on the average, significant difference in effluent is not observed in comparison with the three different types of the aeration tank.

ii) Within a load range of 0. 3 kg BOD/kg SS, significant difference is not observed in the removal efficiency of the complete mixing, plug flow and middle types of aeration tanks which have same detention time and air flow rate, but differences in protozoan fauna and SV are observed (Table 2. 3). Tracers were used to know the mixing characteristics of each system, and the response curve was secured with pulse response as shown in Fig. 2. 1.

iii) As an operation index of the process, studies were conducted on dehydrogenaze activity, such as TTC (2, 3, 5-triphenyl tetrazalium-chloriole) and oxygen consumption activity, and the possibility was explored of applying it to actual treatment plants in the field survey to which reference will be made later. In each instance, the measurement is rather easy, and it may be serve as an index for an operation index of the process.

Another experiment is being conducted on the influence on the activated sludge process by the heavy metals to which reference will be made later.

2. 1. 3 Investigations and Surveys on Sewage Treatment Plants

In the Ministry of Construction, the Public Works Research Institute has been playing the main role in conducting investigation on the existing sewage treatment plants since 1965. Investigation and Surveys have been conducted on two points. One is organization and analysis of collected data on the sewage treatment facilities of each municipality in order to grasp the present status of sewage treatment throughout the nation in a comprehensive manner. This investigation concerns the construction and operation costs of sewage treatment facilities, quantity and quality of the present treatment of sewage and sludge, and treatment capacity of each treatment plant, etc. The survey on the protozoan fauna in each activated sludge treatment plant, to which reference will be made later, has also been conducted in association with this investigation.

The other is a field survey at the actual treatment plants which represent each treatment process, analysis of the data collected at the plants, evaluation of the values used for the design of treatment plants at present and clarification of problematical points by grasping the functions of treatment. It is also designed to obtain information required for improvement measures and make propositions for the designing of treatment facilities. Thirty such surveys have been conducted in these three years at ten treatment plants of both the activated sludge process and the high-rate trickling filter process to examine the incoming waste load and its variation, removal efficiency and hydraulic characteristics at each treatment process, daily variation of BOD reduction rate and oxygen consumption rate in the aeration tanks, mixing characteristics of several types of aeration tank, and material balance in the plant in each treatment system. At the same time, studies have been carried out on the method of a survey on hydraulic characteristics and the operation control index of the activated sludge process.

As for the questions that have not been ascertained in the field surveys, an attempt is to be made for clarification by conducting in laboratory experiments under a restricted condition.

The results of the surveys has been officially announced and informed to each municipality. Besides, they have been incorporated as basic data in the recently published Sewage Treatment Design Manual and comprehensive basin wide sewerage program. The findings of the survey that have been conducted up to this time are summarized in the following:

i) The average values of pollution load per capta, BOD and SS are 39. 5 g/cap/day and 40. 5 g/cap/day, respectively. Nitrogen and phosphrus found as a result of the field surveys, N is 7. 0 g/cap/day and PO_4-P is 1. 1 g/cap/day.

ii) The smaller the scale of the treatment plant, the more conspicuous the change in the incoming load tends to become. This change makes unstable the quality of effluent. The influence to the process by the incoming load variation has been studied in a laboratory experiment where a 60-liter experimental aeration tank and synthetic sewage is used as mentioned earlier.

iii) When the overflow rate is set at 30-50 $m^3/day/m^2$ and the detention time at 1. 0 - 3 hours at primary sedimentation tank, a removal efficiency of SS at 40-55 percent and BOD at 15-30 percent is secured. These values are practically the same as has been expected. Even if the detention time is at more than 2 hours, there might be little improvement in the removal efficiency. The removal efficiency of N and P are somewhat lower than that of BOD.

iv) As a result of the survey on the flow pattern of the primary sedimentation tank using uranin (fluorescein) as the tracer, the possibility of 20 - 50 percent becoming a dead water space is pointed out. This tendency is more conspicuous in the circular and square sedimentation tanks than that of recutanglar ones. (Fig. 2.2)

v) The BOD removal efficiency of the activated sludge process comes within a range of 75 - 95 percent. The quality of effluent in the step-aeration and contact-stabilization processes are almost same as in the conventional a .ivated sludge process. The critical value for the BOD loading of the aeration tank has not been grasped clearly. The removal efficiency of N and P are varied in a broad range.

vi) Initial reduction rate of BOD in aeration tank is expressed as

$$dL/dt = -K_A S_o L$$

where, L;BOD, S_o;MLSS, K_A; BOD reduction constant, t; contact time In actual tanks, K_A were varied in a range of $0.5 - 4.7 \times 10^{-4}$ 1/hour·SS ppm. When the BOD-SS loading exceeds 40 kg/day/SS 100 kg and/or the BOD/MLLS ratio exceeds 40×10^{-3}, there happens a drop in K_A. For a stable treatment, therefore, there is the need to keep the organic load lower than the aforementioned. This means the MLSS concentration in the aeration tank must be controlled properly. (Fig. 2.3) (Fig. 2.4)

vii) In most of the plants BOD, N and P carried back into the aeration tank with return sludge cannot be ignored, and some measure to reduce those lood, such as pre-aeration of return sludge, must be taken into consideration.

viii) In the high-rate trickling filter process, when the hydraulic loading is within a range of 10 - 30 $m^3/day/m^2$, the BOD removal efficiency can be expected somewhere between 65 to 75 percent and that of N within a range of 20 to 30 percent. But the removal of P can not be expected as of nitrogen.

2.1.4 Establishment of Sewage Treatment Plant for Experiment

There are few existing treatment plants which are fitted to the purpose of a specific survey. In many instances, therefore, the analyses of the data obtained in field surveys have had to become qualitative. For this reason, two sewage treatment plants, Sayamadai in Saitama Pre. and Togashira in Ibaragi Prf. both of, which the design population is 22,000 have been selected, and the facilities has been designed for experimental use. In these plants, conventional activated sludge prosess and its modification processes can be taken under same loading condition. Furthermore, instrumentation such as measuring and controlling of flow rate, air volume and quantity of return sludge will be installed adequately.

One of these plants is scheduled to be put into operation in the spring of 1974. These completion is expected to make it possible to secure data which assure an elaborate assessment. It will become feasible to reaffirm the results of the surveys that have so far been conducted in the field and that of the studies which have been conducted on a laboratory scale.

Adequate instrumentation is also provided for investigation to the Arakawa River Left Reaches Regional Sewage Treatment Plant which has 2 million design population and part of it was opened in October, this year. This plant is so designed that a quantitative analysis of the treatment capability may be realized, and it will be put to use as a model of a large-scale treatment plant.

2.1.5 Surveys on Protozoan Fauna

As a link of the surveys on the operation of treatment plants throughout the nation, activated sludge from the each aeration tank were collected and microscopically identified at about 160 treatment plants both in summer and winter of 1971. Activated sludge collected are fixed using the Iodine-Bouin and formalin solutions. The results of these surveys reveal that protozan fauna in Japan have the following characteristics:

i) By microscopic observation, 64 and 4 spiecies of protozoa and metazoa respectively were found in summer. 53 spiecies of protozoa were found in winter. Those with high appearance frequencies are shown in Table 2.4. There is a difference in the appearance frequency of the dominant species between summer and winter.

ii) Regionally, the genous which features a high appearance frequency in summer features practically the same appearance frequency for different areas, but the frequency is different in winter for different areas.

iii) In some plants, it is recognized that the number of genouses and population are smaller in winter than those of in summer and there are a few plants where no protoza were detected at all in winter. This fact shows the activated sludge process are placed under fairly strict conditions in winter.

iv) In comparison with the reports of a survey conducted by Curds in England, the order of the appearance frequency of protoza is different in summer but almost the same in winter.

On the basis of these results, a study is being conducted of the relations between protozoa fauna and the quality of raw sewage or the BOD load of the aeration tank.

2. 2 Improvement in Efficiency and Economy of Aeration of Activated Sludge Process

In Japan, most sewage treatment plant adopt the activated sludge process and it is of much significance to work for an improvement in the efficiency of aeration. The share of electric power in the cost of maintenance and operation of the activated sludge process treatment plant is about 25 percent and most of its share is spent for aeration. Thus it is necessary to work for an upgrading of the efficiency of aeration for the sake of an improvement in the economy.

For this purpose, the Institute established a full-scale experimental aeration tank in 1963.

This equipment, as indicated in Fig. 2. 5, is 5. 6 m in effective width, 3. 5 m in water depth and 2. 0 m in length, and made of steel plates. One side is made of glass plates, thus making it possible to observe the inside during an experiment. The accessories included are a blower unit, a chemical dosing unit, a pulse-type current meter and a DO meter.

At first, an experiment was carried out with the ceramic diffuser plates which are most commonly put to use in Japan. In this experiment, the permeability (cc/min/cm^2) of diffuser plates was set at 300, 600, 1, 200, 1, 800, 2, 400 and 3, 000 so that the plate/water surface ratio could become 5%, 10% and 15%, (one to three rows respectively) and air flow rate was regulated from 3 to 8 times as water.

The results that have so far been obtained are as follows:

i) The greater the permeability of the diffuser plate, the less stable the bubble diameter. It is not so much influenced by the air rate and remains almost constant with the exception of the cases where the permeability is rather small, such as at 300 and 600. The bubble diameters obtained in this experiment are fairly larger than those obtained by Pasver and King (Table 2. 5).

ii) The values of horizontal velocity at the bottom remains constant except when the air flow rate exceeds 6 times as water rate. When the air rate is less than 18 liters/min/m^3, the velocity is observed in a range of 10 to 27 cm/sec. (Fig. 2. 6).

iii) The relation between the air rate and overall oxygen transfer coefficient (Kla) can be expressed in the equation of $Kla = CG^m$, and Kla increases in proportion to the air rate. Kla tends to become larger, when the permeability of the diffuser plate is smaller. For example, there appears a difference of about two times in case the air rate is 20 liters/min/m^3 between permeability 600 and 1200. (Fig. 2. 7)

iv) When Kla is calculated according to King's formula, the value changes, depending on the considered dissolved oxygen deficit. In case the dissolved oxygen deficit is set to 100%, the value calculated according to King's formula agrees fairly with that of actually observed. When the deficit is set to 50%, the calculated value becomes higher than the one observed. The latter is found to be about 75% of the former. (Fig. 2. 8.)

At present, experiments are being conducted in the same manner, while the diffuser has been replaced by a seramic diffusion tube and a nonporous type diffuser. These experiments will make it possible to evaluate the characteristics and efficiency of each type of diffusers.

Profiles of the oxygen level in the aeration tank is related to the rate of the BOD reduction reaction of activated sludge in the aeration tank -- that is, the rate of oxygen consumption. The results of the field surveys at the various treatment plants suggest that the oxygen consumption rate differs at the location of the tank. It decrease gradually from the inlet to outlet. The oxygen consumption rate also differs, depending on the BOD load of influent.

These facts show that more effective aeration is possible by changing the air rate along the aeration tank and controlling the rate in response to the load of influent. At present, studies on the method of the optimum control of aeration in response to the DO level in the aeration tanks and improvement of a blower unit for this control, as well as theoretical study which is attributable to the aforementioned oxygen transfer in the tank and relationship between air flow rate and critical bottom velocity which is necessary to suspend the activated sludge are being conducted.

2. 3 Aspects of Future Studies

2. 3. 1 Activated Sludge Process

It is expected in Japan that the activated sludge process will constitute the main sewage treatment process still in the future. For a water quality preservation in public bodies of waters, there is the need for a higher effulent quality from the sewage treatment plants. To cope with this situation, it is essential to study further on the purification mechanisms of the activated sludge process and the relevant factors, including the effect of influent quality and composision to the process. By incorporating all these factors into one system, it will become possible to systematize the activated sludge treatment process and the prediction of the effluent quality and to find out proper conditions for the maintenance and operation of the plant.

2. 3. 2 Improvement of Existing Treatment Facilities

Of the existing treatment facilities, there are a lot of plants which are already over-loaded and compelled to upgrade their treatment capacity and efficiency. For this reason, it is an urgent task to examine the feasibility of deep aeration tanks and the methods of improving sedimentation tanks. As for the existing treatment facilities, treatment facilities for storm water flow are not taken into consideration. In the future, there will be the need to take note of these points in the facility plans and clarify the quality characteristics of mixed sewage and storm water flow.

2. 3. 3 Combined Treatment of Industrial and Domestic Waste Water

Several examples of combined treatment of industrial and domestic waste water in Japan and the findings of some surveys were introduced to last conference. As it has become gradually evident that heavy metals are accumulated in living bodies, proper measure is to be taken of the treatment of waste water including the heavy metals discharged into municipal sewer. On this problem, the Robert Taft Center has accomplished excellent achievements for many years, and they are of much use when we grapple with this question. But in this study, effect of Cadmium, Lead and Mercury to which serious attention is being paid in Japan today are not included. We have therefore begun studying their behaviors in the biological treatment and their material balance at actual treatment plants.

To achieve combined treatment sucsessfully, there will be the need not only to make efforts on the side of sewage treatment plants but also to strengthen the regulations to the industries and to install monitoring equipment. For this reason, a study is being conducted on the feasibilities of using the monitoring equipments that have primarily been developed for rivers.

2. 3. 4 Maintenance and Operation of Sewage Treatment Plants

Difficulties are being encountered in securing operators for sewage treatment plants in Japan. For this reason, there is the need to automate the treatment process and work out a system in which the maintenance and operation can be conducted with a limited number of operators. Another important task is to find out methods to reduce the cost required for the maintenance and operation and conduct the treatment in an economical manner.

Table 2-1 The Inventory of Sewage Treatment Plants (1969)

Treatment Process \ Capacity 10^3/D		1	1∿5	5∿10	10∿30	30∿100	100∿200	Above 200	Total	%	
Activated Sludge Process	Conventional process	10	16	7	12	11	6	3	65	28.0	71.1%
	Step aeration process	2	7	4	10	16	4	5	48	20.7	
	Contact-stabilization process	2	4	1	1				8	3.4	
	Extended aeration process	8	2						10	4.3	
	Modified aeration process		1		1		1		3	1.3	
	Aeroaccerator	2	9	4	7	6			28	12.1	
	Oxidation ditch	1	2						3	1.3	
High-rate trickling filter		4	13	5	16	4			42	18.1	
Imhoff Tank		1							1	0.4	
Sedimentation			1	5	6	7	3	2	24	10.3	
Total		30	55	26	53	44	14	10	232		

Table 2-2 Synthetic Sewage

Substratum	Concentration	Substratum	Concentration
Glucose	17.6	Urea	37.0
Dextrin	17.6	Kcl	16.2
Beef Extract (Powder)	80.0	$MgSo_4$	5.4
Peptone (Powder)	80.0	$KH_2 PO_4$	24.5
Yeast Extract (Powder)	90.0	NaOH	15.1

unit: mg/ℓ BOD: about 180 mg/ℓ

Table 2-3

	Specifies	Case I		Case II		Case III	
		Effluent	Filtrated Effluent	Effluent	Filtrated Effluent	Effluent	Filtrated Effluent
After 3 days	BOD (mℓ/l)	16.45	5.77	13.09	4.20	12.72	3.25
	COD (")	10.34	10.13	8.67	7.75	11.67	10.63
	T-N Kjeldal (mℓ/l)	8.46	5.66	13.76	5.16	7.28	6.95
	T-P (")	23.75	21.63	22.75	22.00	18.00	16.55
	TOC (")	15.10	11.90	11.10	7.80	13.40	9.90
	TTC-Dt (TFμg/ MLVSSmg)	15.1		14.55		13.1	
	TTC-De (")	10.1		10.6		11.0	
	BOD load (KgBOD/ MLSSkg/D)	0.28		0.27		0.30	
	Removed BOD (")	0.25		0.25		0.28	
	MLSS (mg/l)	2.134		2,220		1,980	
	MLVSS (")	1,484		1,560		1,424	
	SVI	122		130		124	
After 30 days	BOD (mg/l)	12.10	5.00	9.66	3.07	9.65	1.48
	COD (")	15.00	10.00	4.20	3.75	2.95	2.85
	T-N Kjeldal (")	5.38	4.85	7.20	5.32	3.59	3.05
	T-P (")	21.00	19.08	20.75	17.63	15.80	15.53
	TOC (")	11.57	9.99	14.84	12.67	10.83	10.35
	TTC-Dt (TFμg/ MLVSSmg)	10.6		4.6		8.6	
	TTC-De (")	6.0		3.3		6.3	
	BOD load (KgBOD/ MLSSkg/D)	0.33		0.31		0.31	
	Removed BOD (")	0.30		0.29		0.29	
	MLSS (mg/l)	1,845		1,936		1,970	
	MLVSS (")	1,350		1,369		1,470	
	SVI	90		100		96	

Table 2-4 The Protozoan Fauna of Activated Sludge

Summer			Winter		
Genus	Nos. of Sample	Frequency	Genus	Nos. of Sample	Frequency
Epistylis	117	85.5	Momas	83	68.6
Amoeba	116	84.7	Aspidisca	74	61.2
Vorticella	112	81.8	Amoeba	69	57
Aspidisca	108	78.8	Vorticella (Microstoma)	67	55.4
Arcella	86	62.8	Vorticella	56	46.3
Trachelophyllum	86	62.8	Epystilis	55	45.4
Euglypha	71	51.8	Vorticella (Alba)	49	40.5
Tokophrya	65	47.4	Opercularia	38	31.4
Peranema	63	46.0	Trochelophyllum	37	30.1
Monas	47	34.3	Carchesium	25	20.7

Table 2-5

	Existing Data			Result of this Survey	
Permiability	Reporter	Depth (cm)	Mean Diameter of Bubble	Depth (cm)	Mean Diameter of Bubble
600	Pasveer	20	2.4	300	3.30 ∿ 5.23
1200	Beck	45	1.92 ∿ 2.01	"	3.08 ∿ 5.37
	King	90	2.03 ∿ 2.49		
1800	King	90	2.19 ∿ 2.46	"	4.19 ∿ 5.49
2400	King	90	2.54 ∿ 3.96	"	4.74 ∿ 6.38

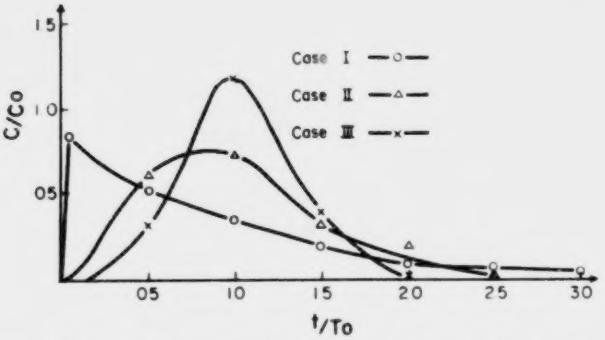

Fig. 2-1 Response Curve of Respective Case

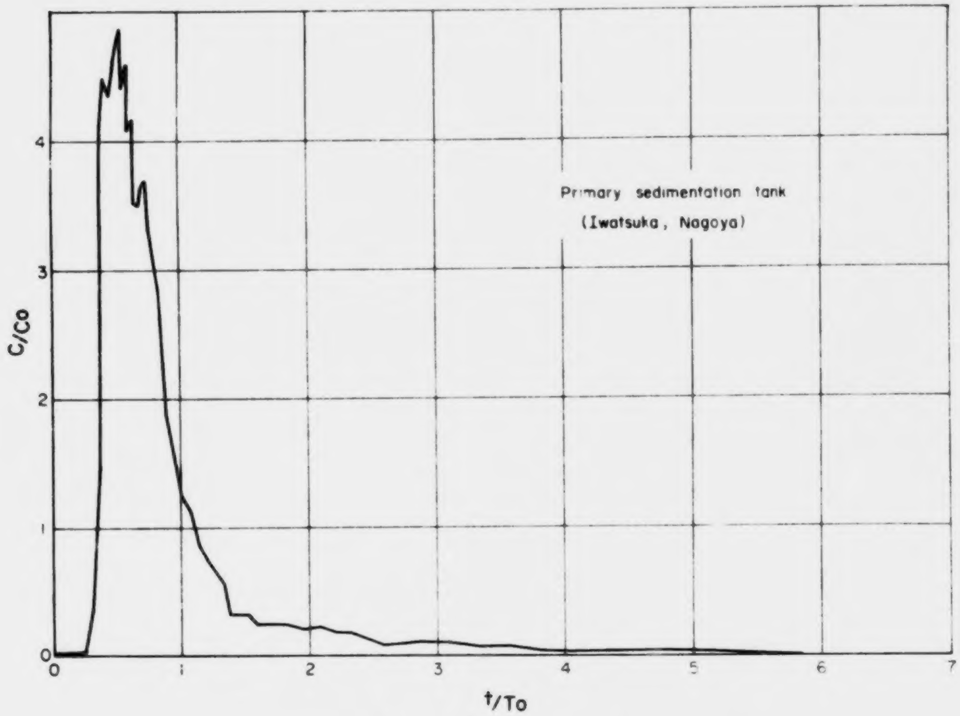

Fig. 2-2 Response Curve

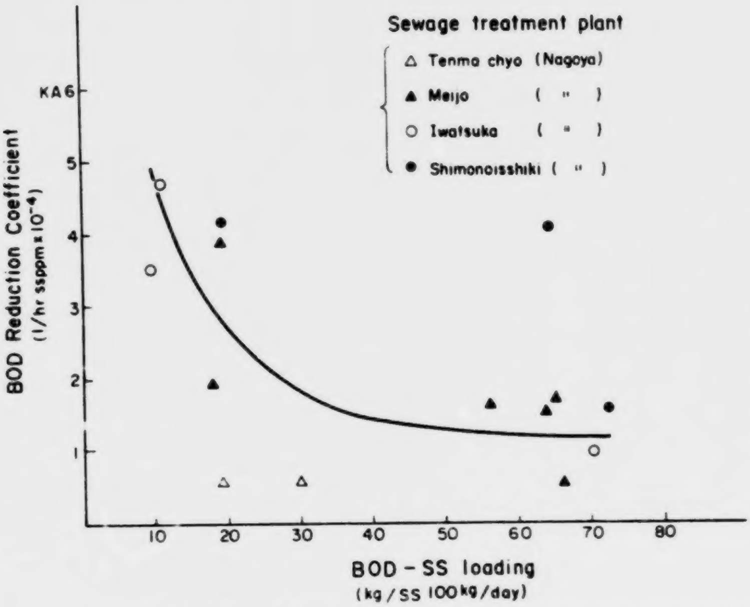

Fig. 2-3 BOD-SS Loading v.s BOD Reduction Coefficient

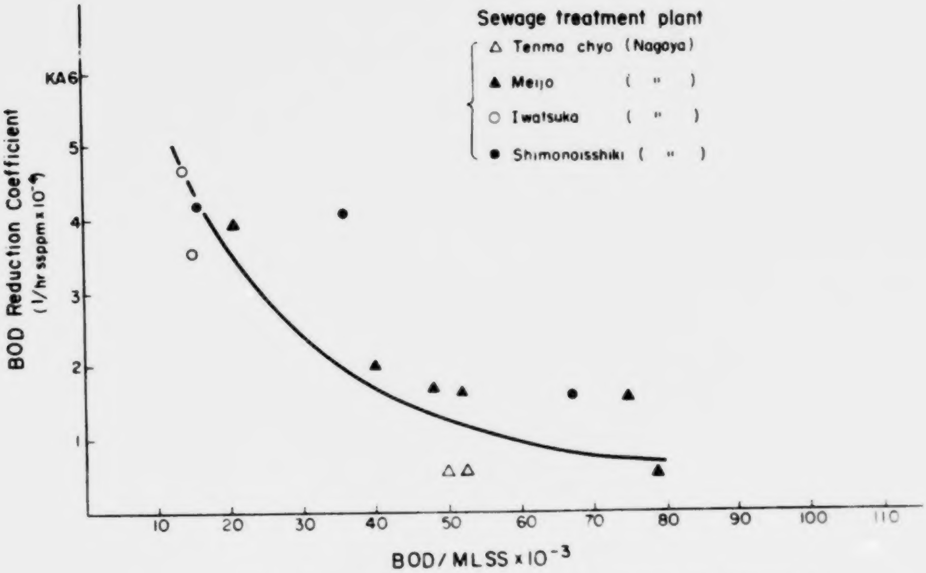

Fig. 2-4 BOD/MLSS v.s BOD Reduction Coefficient

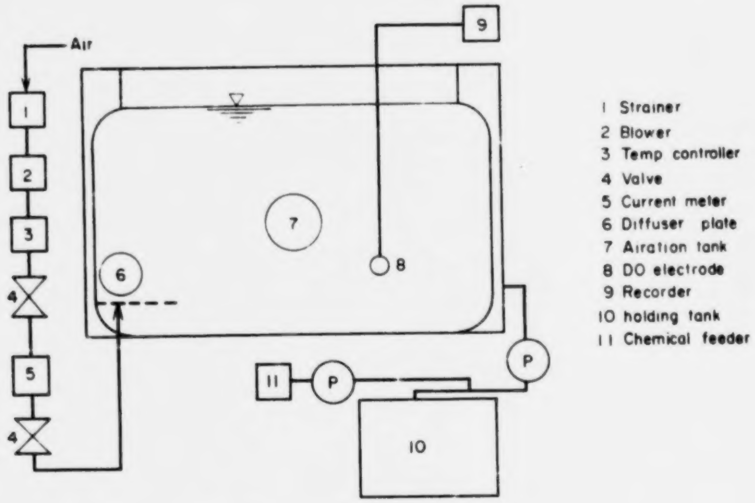

Fig. 2-5 Flow Diagram of the Equipment

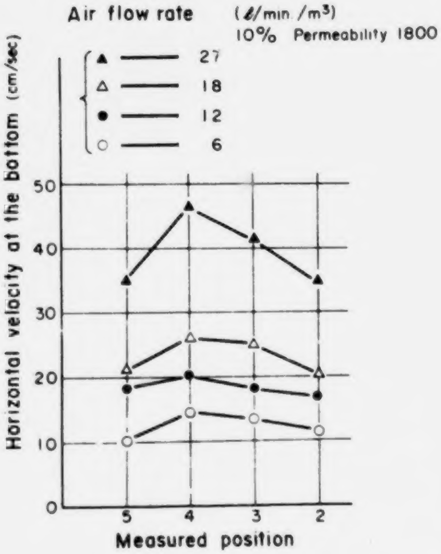

Fig. 2-6 Bottom Velocity v.s. Air Flow Rate

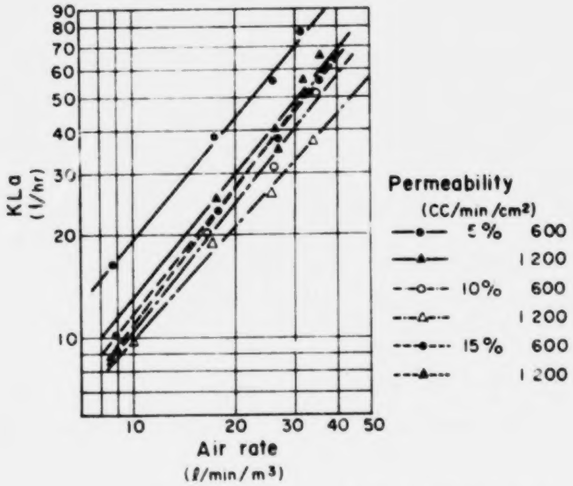

Fig. 2-7 KLa v.s Plate/Water Area

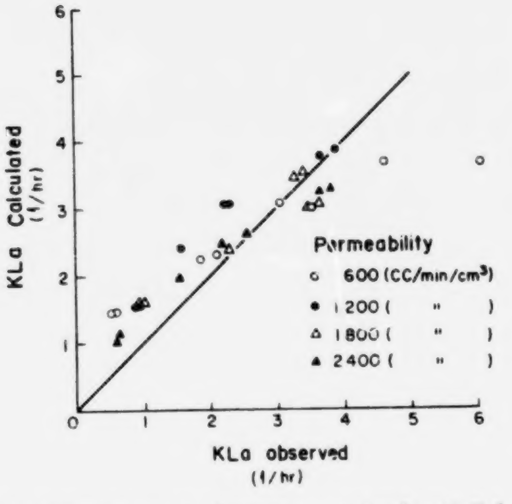

Fig. 2-8 Comparison of Observed & Calculated Value by King's Equation (plate/water area 10%, D.O. deficit 100%)

3. Studies on Treatment and Disposal of Sewage Sludge

3.1 Present Status of Sewage Sludge Treatment and Disposal

The ultimate disposal methods of sewage sludge as of 1967 in Japan were shown in Table 2.6. In a broad classification, methods are land disposal, ocean disposal and agricultural use. As for the ash which is generated in the incinerators, there is no other alternative but to dispose of it in one of the aforementioned methods or a soil or road conditioner.

Reclamation is conducted at sewage treatment plants or seacoasts. It is done at 107 (76%) of 140 sewage treatment plants, and the disposed sludge volume accounts for 70% of the total volume of sludge generated. On the other hand, the sludge volume disposed to ocean accounts for only 1%. Sewage sludge is used as a soil conditioner at 38 plants, and this accounts for 11% of the total volume of sludge generated. Sludge is used as soil condisioner in the local cities on the out-skirts of which there are many farm lands. (Fig. 3.1)

In major cities, it has become increasingly impossible to use their seacoasts for the disposal of sewage sludge and resort to reclamation, and there is an inevitable trend for them to incinerate sewage sludge and reduce the volume as much as possible. Sewage sludge is incinerated into ash at 15 sewage treatment plants, and the amount accounts for 20 percent of the total volume of sludge generated.

Regardless to the ultimate disposal method, drying on the bed or mechanical dewatering is conducted at 99 sewage treatment plants (71%) in Japan after anaerobic digestion, and the volume dewatered by this way accounts for 76% of the total volume of sludge. The mechanical dewatering of raw sludge is conducted at 23 treatment plants, and the volume is 20% of the total volume. (Fig. 3.2) There has been a tendency for major cities and their satellite cities to employ dewatering of the raw sludge due to its economical aspect and the fact that there is no need for digestion tanks and land for them. Whatever systems are adopted for the ultimate disposal, however, there has been a strong call for a revision of the function of the anaerobic digestion process from the epidemiological viewpoint that pathogenes and parasitic eggs should be exterminated. In an administrative ordinance in which the methods for the ultimate disposal of sewage sludge were standardized in 1972, separate standards are set forth for the disposal of incenerated ash and of digested sludge and the sludge cake dewatered directly from raw sludge.

It is expected that the volume of sewage sludge will increase year after year in proportion to the spread of sewage systems in the future. For this reason, the Committee for Investigation into Sludge Handling and Disposal established in the

Japanese Society of Civil Engineers in 1968 has been doing its investigation to work out standards of judgment for the future course by improving and developing the handling and disposal of sewage sludge and handing over its achievements to each municipality.

This committee is formed mainly by sanitary engineers and they are assisted by experts in agriculture, fishery science, mechanical engineering, and metal engineering, and various questions are studied from the viewpoints of their expertise.

3. 2 Studies on Use of Sewage Sludge for Soil Conditioner

These studies are designed to ascertain the effects of sewage sludge when it is used on farms as an organic material for the improvement of soils and to clarify conditions for the use, including the optimum application rate for crops.

A total of 82 series of test have been conducted at the agricultural experiment stations of Kawagoe, Kawasaki, Nagano, Toyama, Fukui, Toyohashi, Gifu, Kagoshima, Sapporo and Sendai cities and on the farms of ordinary farm households since 1969. The tested crops included a total of 25 species, including rice, ordinary upland field crops, leafy, root and head vegetables, petals and fruits.

The findings that have so far been obtained are as follows:

i) The application of sewage sludge accelerates the growth of pratically all crops and tends to result in producing effects for the crops which are sensitive to nitrogen and much in demand. The crops for whose yield the greatest degree of effect is anticipated from the application of sewage sludge are those for whose growth effects are readily anticipated and for which the application is readily tied in with a raise in yield, such as leafy and head vegetables. As for the feeds which are harvested while they are green, effects are also readily anticipated. On the other hand, rice and wheat tend to absorb excessive nitrogen, and effects are also inconspicuous for root crops as their demand for nitrogen is not so great.

ii) The application of sewage sludge results in raising the number of waterproof clods, thus bringing about a raise in the number of hollows. As there are cases in which the cultivability of clay soils is increased, there is not doubt that favoral effects are produced on the physics of soils. The influence on pH of soils cannot be clarified, as $Ca(OH)_2$ is used as an auxiliary agent in the sludge dewatering process and its quantity varies, depending on the treatment plant. In general, there are few changes in pH in paddy fields. As for the upland fields, it is conceivable that pH in soils will essentially be reduced as a result of the formation of nitrate according to inorganization of nitrogen in sewage sludge and the generation of sulphoric acid caused by the oxidation of sulphide. The findings of the surveys on other items reveal that the soils have extremely been eutrificated nutritionally, and it is conceivable that this constitutes the major reason for the production of effects on the growth and yield.

iii) Effects of the application of sewage sludge remain in the subsequent plantations. Therefore, the effects will be accumulated if it is put to continuous use. The continuity of the effects depends on various conditions, but experience shows that the effects remain in the eighth crop four years after the application of 800 kg/are but practically disappear in the sixth crop three years after the application of 100 kg/are. The volumes of application in the tests to upland field crops are indicated in Table 3. 1, and the continuous use of 100 kg/are is a general standard for upland field plantations, such as the plantation of greens.

iv) As the effects of application to crops are concerned, digested sludge dewatered is better than the cake dewatered from raw sludge. The digested sludge of night soils is better than that of sewage sludge. In case sludge is used as soil conditioner, it will be advisable to mix it with soils as much as possible so that the improvement effects may be raised and the localized hazards may be dispensed.

The problems which have been found in the past experiments in association with the application of sewage sludge to agricultural are summarized in the following five items:

(1) Shape of sludge and quality improvement
(2) Scrutinization of hazards to the growth of crops
(3) Elimination of the seeds of weeds and edible fruits
(4) Elimination of plant pathogenes
(5) Elimination of heavy metals

Of them, the fifth subject remains the most important. This question will be given the most serious attention from 1972, and surveys will be conducted on the absorption and accumulation of heavy metals in crops, effects on their yields and the allowable content of heavy metals.

3. 3 Studies on Ocean Disposal of Sewage Sludge

As mentioned in the foregoing, Japan is surrounded by seas and geographically blessed for the ocean disposal. Nevertheless, this method is employed by few cities in Japan. Now that it is expected that difficulties will be encountered in securing the places in land for the disposal of sewage sludge in the future, it will be important to study whether the ocean disposal is justifiable and what effects it will bring about on marine life.

For this reason, surveys have been conducted since 1969 and their findings are compiled this year. The survey consists of a field experiment on the disposal and a laboratory test. The test conducted in the laboratory covers (1) behaviors of sludge in water, (2) effects on benthic matter, (3) hazards to aquatics, (4) accumulation of heavy metals in fish, and (5) possibility of sludge as feeds for marine life.

Field experiment on dispersion of sludge were conducted off Oshima in November, 1969, and October, 1972. 500 m^3 and 1,000 m^3 of sludge with a water content of 96% were disposed at a rate of 1,000 m^3/hr. In this experiment dispersion zone, water temperature, BOD and SS changes, organic acid, ultraviolet ray absorption and microbiotic matter and planktons were measured and examined.

The following points have so far been clarified by the experiment.

i) When raw sludge is dumped into the seas, most of it settles quickly, but about 10% remains suspending. A field survey reveals that sludge remains suspending within the depths of 10 to 30 m (50 m, depending on the location) for one hour. Later, microscopic matter seems to remain in the depths of up to 10 meters. The dispersion is greatly influenced by winds.

ii) In the case of digested sludge, no change is found in benthal matter by dump of sewage sludge for less than 600 g/m^2. Some change is observed for 1,000 g/m^2 and a conspicuous change is observed for 3,000 g/m^2, with the increase of sulphide over 0. 2 mg/g (dry soild).

iii) No adult fish will be killed if the concentration of sewage sludge is less than 10^{-2} (volumetric ratio). But when the avoidance concentration by fish and the influence on initial generation are taken into consideration, it will be necessary to set the ratio at less than 10^{-4}. From the findings of a field survey, it is conceivable that the ratio will become less than 10^{-4} in one hour after dumping.

iv) When the dilution has come to the aforementioned degree, nutrient supply by resolubilization cannot be expected. But, effect as a feed of fish is recognized slightly.

In 1972, the resolubilization of the heavy metals contained in sludge into water, effects on deep-ocean planktons, roes of deep-ocean fish, fries and adult fish, and the further analysis of the field surveys conducted so far on ocean disposals will be carried out to formulate conclusions.

3.4 Studies on Heat Treatment of Sewage Sludge

It is expected that the sedimentability and dewaterbility of heat-treated sludge is conspicuously improved and the work environment is improved as no coagulants are necessary for this dewatering prosess. On the other hand, high-concentration supernatants and their peculiar odor may cause the problems. The facilities established in the cities of Sapporo, Fujisawa and Sakai are used as model plants, and data on the operation of full-scale plants were collected and analyzed and follow-up tests conducted at laboratories to assure a comprehensive assessment.

The design outline of the plant of each city are shown in Table 3.2. The operation was begun in Sapporo City in May, 1971, Sakai City in October, 1971, and Fujisawa City in April, 1972. Summary of the operation data are shown in Table 3.3. The following points have so far been made clear:

i) If the rate of recirculation of heat-treatment supernatants into the activated sludge process is less than 1% of the influent, there is no apprehension that activated sludge will be bulked. The removal of BOD to a fairly large extent is possible, but the COD component which is hard to biodegrade will remain, being dyed in brown. It is conceivable that most of nitrogen will be resolved in the supernatant.

ii) An offensive odor which smells like burned coffee will be generated from heat-treated sludge. As a countermeasure, cooling of heat-treated sludge, incineration of odored air and scrubing at the dewatering chamber were conducted. Metal catalizers were used in conducting an oxidation test at the plant of Sakai City, but no significant effects were observed.

iii) When the temperature of sludge had gone above 160°C, organic matter was stuck by baking like a layer to the outer surface of the inner tube and the inner surface of the outer tube. In the portion where there was a sudden change of sectional area or a bend of tube, erosion was observed. The findings of a survey on the metal plate placed in the reactor for use in the test reveal that the plate is stable at least for six months of use and that no local erosion take place. At present, the cost analysis for maintenance and operation is being carried out on the basis of a full-scale plant. The questions outstanding at present concern (1) safety and durability of equipment -- particularly, burning and erosion of the heat exchanger, (2) countermeasures against offensive odor and (3) handling of supernatant.

This series of surveys will be completed in 1972 to make a comprehensive assessment on the process on the bases of comparison with other processes.

3.5 Aspects of Future Studies

3.5.1 Optimization of Sludge Treatment Process

In addition to the land disposal which constitutes the main disposal process at present, it has become evident that ocean disposal and agricultural use are possible. On the assumption that these disposal processes may be put to use in the future, there is the need to evaluate individual facilities and processes to determine the optimum form of sludge to be disposed and discover an optimum combination of treatment processes. The evaluation of facilities and processes may be conducted by the Sewage Works Corporation.

3.5.2 Load from Sludge Treatment Process

The pollutants which have been removed in the sewage treatment process as sludge, once again come back into the treatment process as supernatant from thickner, digestion tank and dewatering device. They bring about a substantial raise in the load and are occasionally in the form of a shock load. For this reason, it is necessary to clarify the effect of the load from the sludge treatment process upon the sewage treatment process. Depending on the circumstance, it may be necessary to treat separately the waste water from sludge treatment facilities.

3.5.3 Handling of Sludge Containing Heavy Metals

The heavy metals concentrated in sludge bring about an influence on the maintenance and operation of digestion tanks and other facilities. In addition, it is quite possible that they will be resolubilized in thetreatment process and after disposal. Therefore, it is necessary to clarify the behaviors of heavy metals at the times of sludge treatment and after disposal and to find out countermeasures.

Table 3-1

Status of Sewage Sludge Treatment and Disposal

Method of Disposal	Method of Treatment	Number of Plants	Raw Sludge Volume (10^3m^3/Year)	Treated Sludge Volume (10^3m^3/Year)
Utilization for Agriculture	Drying Bed	2	61	0
	Dewatering of Raw Sludge	3	65	1.5
	Anaerobic Digestion and Drying Bed	10	753	5.5
	Anaerobic Digestion and Dewatering	24	2,844	37.4
Disposal into Ocean	Raw Sludge	1	30	29.7
	Aerobic Digestion	2	3	1.7
	Anaerobic Digestion	1	343	10.6
Landfill	Raw Sludge	5	76	26.1
	Drying Bed	10	202	3.8
	Dewatering of Raw Sludge	15	2,805	64.1
	Aerobic Digestion	1	15	1.1
	Aerobic Digestion and Dewatering	5	242	4.6
	Anaerobic Digestion	3	379	8.6
	Anaerobic Digestion and Drying Bed	20	1,291	18.8
	Anaerobic Digestion and Dewatering	54	18,514	370.8
Incinerated Ash	Raw Sludge	9	2,242	76.7
	Anaerobic Digestion and Dewatering	8	4,017	53.9
Total		140	33,282	714.9

Note: Raw Sludge Volume is calculated from 99% of moisture, but treated sludge moisture are varied.

Table 3-2 Design Basis of Heat Treatment Facilities (1st Stage)

Design Basis	Toyohiragawa, Sapporo	Senpoku, Sakai	Nanbu, Fujisawa
(1) Sludge Condition			
Water content of concentratedraw sludge (%)	95	96	96
Sludge volume (m^3/day)	403	196	144
Water content of concentrated sludge (%)	90	90	92
Sludge volume	161.2	54.9	57.7
Water content of dewatered sludge (%)	<47	50	40
Cake volume (DS-t/day)	30.4	9.97	7.2
(2) Heating Condition			
Raw sludge (°C)	10	15	20
Heated sludge (°C)	165	160	160
Inside of reactor (°C)	200	200	200
Refrigerated sludge (°C)	-	effluent+15	25
Detention time in reactor (min.)	45	30∿60	60∿120
(3) Unit			
Heat exchanger	Counter current dual pipe 16.8 m^3/h x 18 kg/cm^2 x 220 m^2	Counter current dual pipe 10 m^3/h x 18 kg/cm^2 x 165 m^2	Counter current dual pipe 3∿10 m^3/h x 18 kg/cm^2 x 150 m^2
Reactor	Vertical cirindrical type ϕ1798x7000x 6.8 m^3	Vertical cirindrical type ϕ1600x7000x 12.5 m^3	Vertical cirindrical type ϕ1750x7000x 14 m^3

Table 3-3 Result

	Toyohiragawa, Sapporo	Senpoku, Sakai	Nanbu, Fujisawa
Temperature (°C)	195 ∿ 200	180	200
Detention time (min)	30	40	-
Water content of heated sludge (%)	94	94.64	85 92
Water content of sludge cake (%)	36.1	44.07	35.6
Supernatant BOD (ppm)	6000	5747	4000 ∿ 6000
Effluent BOD (mg/L)	13.0	-	6.6

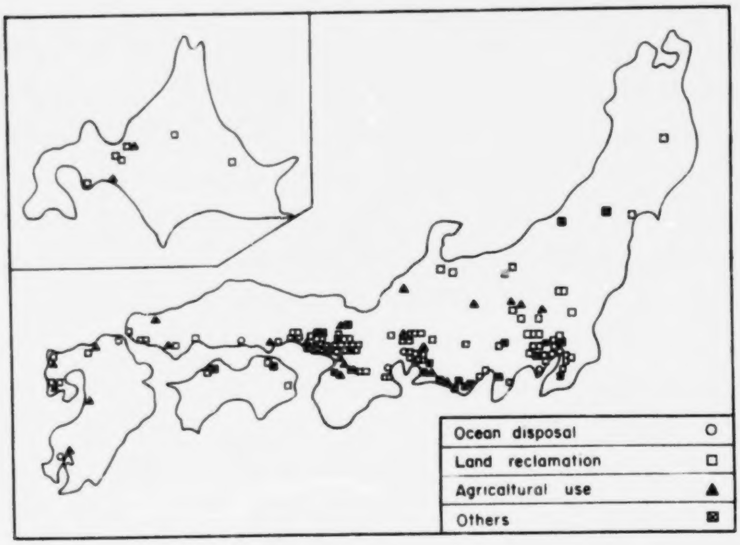

Fig. 3-1 Method of Disposal

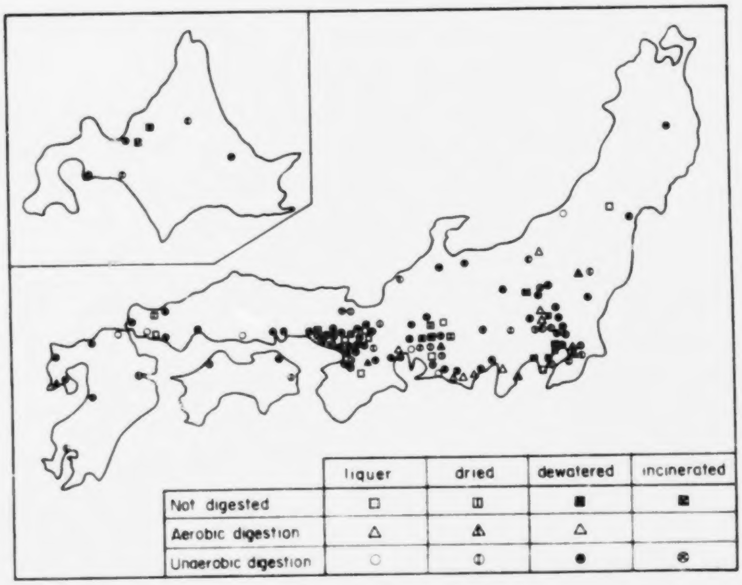

Fig. 3-2 Method of Treatment

4. Studies on Water Pollution

4.1 Water Pollution in Streams

As the result of concentration of population to urban area as well as rapid growth of industrial production which began from about 1960, the demand for water supply has been increasing year by year making the development of water resources be one of key problem. On the other hand, however, the increase in water demand has resulted in the increasing discharge of both domestic sewage and industrial wastes into rivers, which brought about the growing trend of pollution in water quality in many rivers. This circumstance necessitated the evaluation of water quality in order to maintain the normal and proper function of rivers, and moreover, to carry out precise estimation of future water quality. The study on water quality pollution in rivers has been performed by the Public Works Research Institute and Regional Construction Bureaus to achieve this object. The problems dealt with in this study are as follows.

i) To investigate BOD reduction coefficient in rivers

ii) To evaluate reaeration phenomenon in streams and obtain a practical formula for reaeration coefficient.

iii) To evaluate the reaeration phenomenon at weirs attending to the fall of river water from dam, and obtain a practical expression to formulate the phenomenon.

iv) To promote the development and practical application of automatic monitor of water quality of rivers.

Of the above, items i) and ii) consist the survey on the oxygen demand and oxygen balance in river water. They have been performed aiming at adapting the basic equation proposed originary by Streeter-Phelps to rivers in Japan.

4.1.1 Survey into BOD reduction coefficient in rivers

Survey into BOD reduction coefficient in rivers has been carried out for about 3 years, and the actual measurement was performed for about 30 rivers in area covering from Hokkaido to Kyushu. In this survey, reaches were selected where there were cities or works located on the upstream and the BOD within the reach was more than 2 mg/l. As the survey items, besides the hydrographical conditions such as average velocity, average water depth, average gradient, coefficient of roughness, average diameter of river bed material, etc., the observation of water temperature, VDS, VSS, BOD, dissolved BOD, deoxygenation coefficient (k_1), algea flora on bed material, has been performed. On the basis of these survey, the following items on the BOD reduction coefficient k_r in the river have been found out.

(a) BOD reduction coefficient (k_r) in rivers is usually far greater than the deoxygenation coefficient (k_1) measured in a laboratory. Accordingly, even in rivers with relatively small length and steep gradient, decrease in BOD due to sedimentation and/or microbe on river bed is fairly great.

(b) Taking the ratio of k_r to k_1, (k_r/k_1), certain trend is discernible between k_r/k_1 and average depth, although the range is wide. Generally speaking, the greater the average depth, the k_r/k_1 is the smaller, and where average depth is 3m or more, k_r is nearly equal to k_1. (Fig. -4. 1)

(c) As the average velocity within the reach surveyed was 0. 4 m/sec or greater, no significant correlation was discernible between k_r/k_1 and average velocity.

(d) On the average, k_r was larger in rivers where BOD was high. Besides, most of the algae on the bed was blue-green algae in rivers with large k_r

(e) No definite correlation was found between the number of algeas and k_r.

4. 1. 2 Reaeration in Streams

For the purpose of evaluating the reaeration in streams and obtaining the reaeration coefficient, a number of theoretical formula, semi-theoretical formula and experimental equation have been proposed. Among these, there are formulae of U. S. Geological Survey, Churchill et al, and O'Connor & Dobbins (for isotropic turbulence and non-isotropic turbulence). The applicability of these formulae was at first, examined using data obtained from flume experiments and field surveys.

As shown in Fig. -4. 2, U. S. Geological Survey's formula gives coefficients which are approximately proportional to the measured values although the absolute values are about twice as large as measured values, and the formula seems to express fairly well the change in reaeration coefficient corresponding to the fluctuation in hydraulic conditions.

The formulae of O'Connor & Dobbins (isotropic turbulence) and Churchill et al are of similar inclination, and measured value thereof in rivers agrees relatively well with the calculated value, but the measured value in the experimental flume is different from calculated value. The formula of O'Conner & Dobbins (non-isotropic turbulence) gives, to the contrary of the above, nearly the same calculated values as these measured in the experimental flume, whereas the measured value in rivers is considerably different from the calculated value (Fig. -4. 2) Since none of above formulae are not universal, a theoretical study has been performed to develope a formula which is applicable in any case.

This study is based also on surface renewal theory as those of O'Conner & Dobbins and Dobbins were. The assumptions which may be questionable in the theory of O'Connor & Dobbins is that the logarithmic distribution of velocity is applied even to surface (in the case of non-isotropic turbulence), and that velocity fluctuations and scale of turbulence are assumed uniformly to be 10% of average velocity and depth, respectively (in the case of non-isotropic turbulence). On the other hand, Dobbins assumed that the thickness of liquid film was equal to the dissipation scale of eddies given by Kolomogoroff. However, the parameters ruling the size of eddies on the very surface are supposed to include surface tension, which means that Dobbins' assumption may also be questionable.

According to the surface renewal theory, the oxygen transfer rate K_L is expressed as follows:

$$K_L \propto \sqrt{D_M r} \qquad \ldots\ldots\ldots \qquad (4.1)$$

in which D_M is molecular diffusion coefficient and r is surface renewal rate. In order to express r as a function of hydraulic parameter, following assumption were made:

(i) Since surface tension works on free surface, the flow mechanism in the surface layer, of which thickness may be extremely thin, is different from that in the main stream. In the surface layor, surface tension is the only parameter to cause the dissipation of turbulence.

(ii) In the surface layor, velocity fluctuation in vertical direction is proportional to the distance from the surface, and the scale of eddies is inversely proportional to the distance.

(iii) The velocity fluctuations at the boundary between the surface layor and the main stream may be due to various scales of eddies. But eddies which affect reaeration predominantly are those with high frequency, and these eddies are represented by the eddies of dissipation scale.

(iv) Energy dissipation rate is represented by Manning's formula for average velocity.

On the basis of above assumptions, K_L of Eq. 4.1 and reaeration coefficient K_2 may be expressed as follows:

$$K_L = C' \frac{g^{3/8} \rho^{1/2} \gamma^{3/8} D_M^{1/2} n^{3/4}}{\sigma^{1/2}} \cdot \frac{U^{9/8}}{R^{1/2}} \qquad \ldots\ldots \qquad (4.2)$$

$$K_2 = C' \frac{g^{3/8} \rho^{1/2} \nu^{3/8} D_M{}^{1/2} n^{3/4}}{\sigma^{1/2}} \cdot \frac{U^{9/8}}{H. R^{1/2}} \quad \ldots\ldots\ldots \quad (4.3)$$

where g is the acceleration of gravity (m/sec^2), ρ is the density (kg/m^3), ν is the kinetic viscosity (m^2/sec), n is the Manning's roughness coefficient ($m^{-1/3}$ sec), σ is the surface tension (kg/sec^2), U is the average velocity (m/sec), H is the average depth (m) and R is the hydraulic radius (m). The constant C' in Eq 4.3 was determined to be 3.21×10^5 by flume experiments when K_2 is expressed in 1/day (e base) and other parameters are expressed in MKS units.

Taking the values of the parameters at the temperature of 20°C and assuming that R is equal to H, Eq. 4.3 reduces to:

$$k_2 = 22.56 \; n^{3/4} U^{9/8} / H^{3/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.4)$$

where k_2 is in 1/day (10 base).

The comparison of reaeration coefficients observed in actual rivers with those calculated by Eq. 4.4 is shown in Fig. -4.3.

4.1.3 Reaeration at Weir

It is quite common in Japan that there are many small scale weirs in a river for intake of irrigation water. The detention time in these small reservoirs is usually from less than one hour to several hours. The quantitative evaluation for the effect of these small reservoirs upon water pollution has not been made fully so far. However, in recent years, the study on reaeration at weir and the study for checking the possibility of utilizing these small reservoirs as a kind of sedimentation tank for organic suspended matter removal are being advanced.

Reaeration at weir has been studied using a experimental weir. From this experiment, it was found that the dissolved oxygen recovery ratio R which is the ratio of oxygen deficit in the water below the weir to that above the weir, may be expressed in the following way.

$$R = 10^{-CH} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.5)$$

where H is the height (in m) through which the water falls and C is the reaeration coefficient of weir (in 1/m).

The coefficient C is a function of many factors including temperature. The effect of temperature was found, from laboratory experiment, to be corrected by the following equation.

$$C_T = C_{20} (1.016)^{T-20} \quad \ldots\ldots \quad (4.6)$$

Where, C_T : Reaeration coefficient of weir at the temperature of T°C,

C_{20}: Reaeration coefficient of weir at the temperature of 20°C.

It seems that bubble aeration in the water cushion has significant effect on the overall recovery of dissolved oxygen. In fact, the coefficient C becomes large with the increase in the depth of water at the point of fall until certain depth. As the reaeration at weir is also influenced by other factors such as the shape of weir and quality of water, experiment is now being continued in various cases.

4.1.4 Automatic Water Quality Monitor

At present, there are more than one hundred automatic water quality monitors in Japan. Among these, 40 monitors are installed along the first class rivers which are directly managed by the Ministry of Construction. It is expected that the number of automatic water quality monitors will increase rapidly in future.

Most of the monitors are of shore base type. The parameters measured are usually: water temperature, electric conductivity, pH, dissolved exygen, turbidity, free cyanide and ammonia. There still remain a lot of problems, especially in pumps, holding tank, and sensors, and futher study has to be done. As for the pump, it is very difficult to operate it for a long period without any trouble such as clogging and disorder. Rivers in Japan carry sometimes large amount of sand and many pieces of floating wood, which obstruct proper operation of pumps. At present, dual systems of pump and water line are provided to operate altenatively, and cleaning is done while one is not in operation. However, even dual systems are applied, large diameter pumps should be used in order to operate them without trouble, resulting in uneconomical condition. The major purpose of a holding tank is to remove comparatively large floating substances which might cause troubles if the feed water to flow-cells would contain them. In the present system, three screens with different meshes are provided inside the tank, but mesh size of screens and the preventive method of mesh clogging have to be investigated further.

There are 7 manufacturers in Japan who are producing automatic water quality monitors. Most of the manufacturers use their own sensors but some buy the products of other companies (foreign companies). Thus, the precision, reproductivity, and durability are not uniform. Moreover, the method of cleaning is different depending on the manufacturer, that is, cleaning by water jet or supersonic waves, or both methods, and it is not yet clear which one is the most suitable. Therefore, the Public Works Research Institute is carrying out a comparative test, under the same condition, of monitors produced by 7 manufacturers and investigating the accuracy, reproducibility and durability of each monitor, and the methods of cleaning.

On the basis of the results of this test, the standardization of automatic water quality monitor is being proceeded. The automatic water quality monitors for sewage flowing into a treatment plant and for industrial waste water being discharged into pablic sewerage system are also being developed.

4. 2 Water Pollution in Lakes

It is the present situation that representative lakes in Japan such as Lake Biwa, Lake Suwa and Lake Kasumigaura arê being entrophicated gradually and effective counter measures are being looked for. Under these circumstances, study has been going on from the limnological, ecological and sanitary engineering point of view.

Among these lakes, the most comprehensive survey is being conducted with respect to Lake Kasumigaura. Kasumiga-ura is the second largest lake in Japan, located about 60 km apart from Tokyo in northwest and is composed of 3 lakes, that is, Nishi-ura, Kita-ura and Sotogasaka-ura, connected each other with Hitachi Tone River and Wani River (Fig. -4. 4).

Lake Kasumigaura is a shallow lake which has a storage capacity of 873 x 10^6 m^3, with average depth of 4 m and maximum depth of 7 m. It has been used for fishing from old times, and is designated as a National Park. This lake is a important water resource and intake of water for water supply, industrial and agricultural purposes has been made. In addition, under the new water resources development plan commenced in 1970 construction works are now in progress in order to develope new water resources amounting about 40 m^3/sec. Table-4. 1 represents the present status of each lake and their basins.

Lake Kasumigaura has originally been a slightly eutropic lake, but recently, the eutrophication has been accelerated.

Figure-4. 5 shows the change in COD (potassium permanganate method) at the intake point of water supply and Fig. -4. 6 shows the change in the cost of chemicals for water treatment. As shown in Fig. -4. 5, COD is much higher than 3 mg/l which is the water quality standard for the body of water utilized for large scale water supply. As the chemicals for water treatment, aluminium sulfate can not be used any longer and poly aluminium chloride (PAC) is being used. In addition, it is sometime necessary to use powdered activated carbon.

The Public Works Research Institute and Kanto Regional Construction Bureau have begun a comprehensive curvey since 1971. The major purposes of this survey are to make clear the mass balance of each pollutant in the lake, to find out the causing materials of entrophication, to develope a simulation model for water quality and to clarify present biological condition in the lake.

The whole project is consisted of the following surveys.

(i) Survey on quality and quantity of water of inflowing and outflowing rivers:
Quality and quantity of 59 inflowing rivers and 3 outflowing rivers are investigated by 24 hr surveys 4 times a year. In addition, automatic samplers which are capable of taking samples every hour are installed at the mouth of 3 typical inflowing rivers and 3 outflowing rivers, and 24 hr composite samples are analyzed every day. This work is continually performed through out a year.

(ii) Water quality survey of the Lake:
Quality of the lake water is investigated at 15 fixed stations by 24 hr surveys 4 times a year. In this survey, besides the major parameters such as BOD, COD, TOC, phosphorus and nitrogen, elements which may be related with entrophication, such as calcium, sodium, magnesium, cobalt, silica, vanadium, morybdenum, etc. are analyzed. In addition, grab samples are taken at several stations once a month and analysis is made on principal items.

(iii) Survey on bottom deposits:
The distribution, thickness and constituents of bottom deposits are investigated. The relashionship between the amount of resuspension of the sediments and the wind velocity and wind direction are studied by field observation. The dissolved oxygen consumption by bottom deposits and resolubilization of pollutants from them under both deposited state (aerobic and anaerobic conditions) and resuspended state are studied by laboratory experiments.

(iv) Biological survey in the Lake:
Survey is made on the primary production, zoo-and phyto- planktons, protozoa, benthos, bacteria and rooted plants.

(v) Survey on Pollution Load:
Survey is made on the sources of pollution such as domestic sewage, industrial waste water, effluent from night soil treatment plants, return flow of irrigation water and livestock raising waste water, as well as the degree of treatment of these wastes at present. In addition, the pollution

load by cultured fishes (carp) in the lake and those from rain-water, under ground water and mountain-stream are also investigated.

A part of the results of above surveys is shown in Fig. -4. 7 and Table-4. 2. Fig. -4. 7 shows the pollution loads being discharged from major inflowing rivers in Feb. 1972, and Table-4. 2 shows the 24 hr-average water quality of the lake in February and May, 1972. Water quality in summer when the temperature is high and the return flow of irrigation water flows into is considered be worse than that shown in Table-4. 2. As shown in Table-4. 2, nitrogen concentration is very high, whereas phosphorus concentration is relatively low compared with other elements. However, phosphorus concentration will increase in summer due to the return flow of irrigation water and resolubilization of phosphate from bottom deposits. In fact, abnormal growth of algea was observed in the summer of 1971.

In the Kasumigaura basin, a comprehensive plan for sewerage system is being examined. However, the largest problem in this basin is the livestock raising wastes. As shown in Table-4. 3, the pollution load from the livestock raising consists a considerable portion of total load. These livestock are raised by about 34, 000 farming households scattered in the basin, and the water pollution prevention of Kasumigaura depends on how to treat such livestock raising wastes and control the discharge of organic substances and nutrients into the lake.

The final report of this survey is to be published by the end of 1973 and the detail results will be presented at the next meeting of U. S. -Japan conference on the Sewage Treatment Technology.

4. 3 Studies on Water Pollution in Estuaries and Seas

4. 3. 1 Simulation of Water Quality

Surveys on the forecasting the water pollution of the Sumida River which runs through Tokyo were conducted by the Kanto Regional Construction Bureau and the Public Works Research Institute of the Ministry of Construction from 1962 to 1966. As reported previously to the UJNR Water Pollution Panel Meeting, the model developed by Preddy et al. for the computation of water pollution of the Thames Estuary was put to use.

As the Sumida River has a relatively long estuary of intense mixing type, the model developed for the Thames Estuary could be applied. However, most of the estuaries in our country are short, and there are many cases where this model cannot be applied. There has also arisen the need for the simulation of water quality in the seas.

At present, studies are being conducted on the possibility of solving the unsteady dispersion equation numerically. In the case when the velocity, dispersion coefficient, cross sectional area and water depth are dependent on both time and space, the one-and two-dimensional dispersion equations are expressed as follows, respectively:

$$\frac{\partial(AC)}{\partial t} + \frac{\partial(AVC)}{\partial x} = \frac{\partial}{\partial x}\left(AD\frac{\partial C}{\partial x}\right) \quad \cdots\cdots\cdots\cdots \quad (4.7)$$

$$\frac{\partial(HC)}{\partial t} + \frac{\partial(HV_xC)}{\partial x} + \frac{\partial(HV_yC)}{\partial y} = \frac{\partial}{\partial x}\left(HD_x\frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(HD_y\frac{\partial C}{\partial y}\right) \cdots\cdots \quad (4.8)$$

where A is the cross sectional area, C is the concentration, t is time, V is the velocity, D is the dispersion coefficient, H is the water depth, and x and y are the space coordinates.

Eqs. 4.7 and 4.8 are transformed to finite difference equations in order to solve them numerically.

One of the most significant contributions to the numerical computation of the dispersion equation is the introduction of a concept of pseudo-dispersion proposed by Bella. This error is caused by the fact that in numerical computation, concentration is not given as a continuous function of the distance. The magnitude of this error is different depending on the method of finite-difference modelling. In any case, however, it can be expressed in the form of a dispersion coefficient and this coefficient is called as pseudo-dispersion coefficient (D_N). It is known that this error can be corrected by using in the calculation a dispersion coefficient obtained by subtracting the pseudo-dispersion coefficient from the actual coefficient.

The numerical computation method developed by the Institute for the computation in the estuaries and seas uses Bella's method for the correction of pseudo dispersion. However, the technique to prevent the oscillation in the computation is different, that is, to use an explicit scheme for the convection term and an implicit scheme for the dispersion term. This method has been proved to give satisfactory results. (The method of Bella is to perform separate computations for the convection and dispersion terms respectively to avoid an oscillation in the computation).

In the case of the one-dimensional equation, the finite difference form is expressed as follows:

$$C_{i,k+1} = C_{i,k} + \frac{V\Delta t}{\Delta x}\left(C_{i-1,k} - C_{i,k}\right) + \frac{(D-D_N)\Delta t}{\Delta x^2}\left(C_{i-1,k+1} - 2C_{i,k+1} + C_{i+1,k+1}\right)$$

$$\cdots\cdots\cdots\cdots\cdots\cdots \quad (4.9)$$

where $D_N = \frac{V\Delta x}{2}\left(1 - \frac{V\Delta t}{\Delta x}\right)$, $x = i\Delta x$ and $t = k\Delta t$. In the above equation, velocity and other hydraulic parameters are kept constant for the sake of simplicity of expression. When the decay term is included it is added directly to the equation.

In the case of the two-dimensional equation, the computation of the one dimension is repeated in the x and y directions alternatively. The difference equations are written as follows:

$$C'_{i,j} = C_{i,j,k} + \frac{V_x \Delta t}{\Delta x}\left(C_{i-1,j,k} - C_{i,j,k}\right) + \frac{(D_x - D_{Nx})\Delta t}{\Delta x^2}\left(C'_{i-1,j} - 2C'_{i,j} + C'_{i+1,j}\right) \quad \cdots\cdots\cdots \quad (4.10)$$

$$C_{i,j,k} = C'_{i,j} + \frac{V_y \Delta t}{\Delta y}\left(C'_{i,j-1} - C'_{i,j}\right) + \frac{(D_y - D_{Ny})\Delta t}{\Delta y^2}\left(C_{i,j-1,k+1} - 2C_{i,j,k+1} + C_{i,j+1,k+1}\right) \quad \cdots\cdots\cdots \quad (4.11)$$

where $D_{Nx} = \frac{V_x \Delta x}{2}\left(1 - \frac{V_x \Delta t}{\Delta x}\right)$, $D_{Ny} = \frac{V_y \Delta y}{2}\left(1 - \frac{V_y \Delta t}{\Delta y}\right)$,
$x = i\Delta x$, $y = j\Delta y$, $t = k\Delta t$ and $C'_{i,j}$ is the hypothetical concentration affected by the convection and the dispersion in x direction only. In the above equations, again for the sake of simplicity of expression, velocities and other hydraulic parameters are assumed to be constant. By using Eq. 4.10, the concentration $C'_{i,j}$ is calculated for each point, and then, the concentration after a time period of $C_{i,j,k+1}$ is calculated by Eq. 4.11. In the case when the decay term is included in the equation the term is divided into two and added to the equations 4.10 and 4.11 respectively.

This model is being applied to estuaries such as the Ota River and bays such as Tokyo Bay, and will be applied widely in the near future.

4.3.2 Water Pollution Survey of Tokyo Bay

The water pollution survey of Tokyo Bay was initiated in October, 1970 jointly by the Sewerage Department of the City Bureau, the Kento Regional Construction Bureau and the Public Works Research Institute, and will be continued until March, 1973.

Tokyo Bay, like Osaka Bay, is a bay with one of Japan's most densely populated area in its hinterland. Its basin includes the Keihin and Keiyo industrial zones, and industrial production in the area is tremendously enormous. As the result, the water pollution of this bay has been taken as a grave issue and it was decided to carry out a comprehensive survey for about three years in order to grasp the present status of the water pollution as well as hydraulic characteristics of the Bay, and further to formulate plans for the prevention of water pollution in the future. The items to be examined in this survey are as follows:

i) Survey on the present status of water pollution in the bay

Survey on water quality in the bay:

Twice a year in summer and winter.

Period and interval of sampling: 25 hours (about 2 tidal cycles) with an interval of 2 hours.

Numbers of sampling stations: Sampling by fixed boats at 21 stations with sampling at 3 locations in vertical direction, sampling by moving boat at 20 stations with sampling at 2 locations in vertical direction.

Water qualit parameters measured: water temperature, color, transparency, pH, COD, DO, BOD, chloride ion, total phosphorus, total nitrogen, nitrogen (albminoid), nitrogen (ammonia), nitrogen (nitrite), nitrogen (nitrate) and oil and grease

Survey on bottom deposits:

Measurement of sludge thickness at 30 stations

Analysis of bottom deposits samples of 20 stations

Items surveyed: COD, total phosphorus, total nitrogen, cadmium, lead, arsenic, total mercury, total cyanide

Survey on tidal current in the bay:

19 observation stations with measurement at one or two locations in vertical direction.

25-hour continuous observations of velocity and its direction.

As a part of the results of this survey, the distributions of DO, BOD, COD and chloride ion in the upper layer (20% of the depth) in winer are shown in Fig. 4. 9, 4. 10, 4. 11 and 4. 12, respectively.

ii) Survey on Pollution Loads

Survey on rivers flowing into the bay:

Number of rivers surveyed: 32

Flow measurement: 25-hours measurement at an interval of 1 hour.

Sampling: 25-hour sampling at an interval of 2 hours

Water quality parameters measured: water temperature, pH, COD, BOD, DO, suspeded solids, total phosphorus, nitrogen (ammonia), nitrogen (nitrite), nitrogen (nitrate), chloride ion

Survey on industrial wastes directly discharged into the Bay:

Number of plants surveyed : 50

Water quality parameters measured: water temperature, pH, COD, BOD, DO, suspended solids, total phosphorus, total nitrogen

Survey on sewage treatment plants:

Number of treatment plants surveyed: 7

Water quality parameters measured: (the same as those in the survey on industrial wastes)

iii) Survey on the Effect of Bottom Deposits on Water Quality

Resolubilization of organic pollutants and nutrients are being studied experimentally (in a laboratory scale) under the various condition of overlying sea water, such as aerobic or anaerobic, and with velocity or without velocity.

Term of experiment: 63 days

Temperature: 20°C

The items surveyed: BOD, COD, total phosphorous, orthophosphate, total nitrogen, nitrogen (amonia), nitrogen (nitrite), nitrogen (nitrate)

iv) Computation of Tidal Current in the Bay

The numerical computation of tadal current has been done in order to give the velocity and depth data to the computation of the dispresion equation. The equations of continuity and motion used in this calculation are as follows:

$$\frac{\partial \zeta}{\partial t} + \frac{\partial M}{\partial x} + \frac{\partial N}{\partial y} = 0 \quad \cdots\cdots (4.12)$$

$$\frac{\partial M}{\partial t} = fN - g(h+\zeta \frac{\partial \zeta}{\partial x} - \gamma_b U \sqrt{U^2+V^2} - (h+\zeta)\left(\frac{\partial U^2}{\partial x} + \frac{\partial UV}{\partial y}\right) + L\left(\frac{\partial^2 M}{\partial x^2} + \frac{\partial^2 M}{\partial y^2}\right) \cdots (4.13)$$

$$\frac{\partial N}{\partial t} = -fM - g(h+\zeta)\frac{\partial \zeta}{\partial y} - \gamma_b V \sqrt{U^2+V^2} - (h+\zeta)\left(\frac{\partial UV}{\partial x} + \frac{\partial V^2}{\partial y}\right)$$

$$+ L\left(\frac{\partial^2 N}{\partial x^2} + \frac{\partial^2 N}{\partial y^2}\right) \quad \cdots\cdots (4.14)$$

where M and N are defined as follows:

$$M = \int_{-\zeta}^{h} u\,dz = U(h+\zeta), \quad N = \int_{-\zeta}^{h} v\,dz = V(h+\zeta)$$

in which h is the mean water depth, ζ is the vertical distance from the water level to the mean water level, f is Colioli's coefficient, g is the acceleration of gravity, u and v are the velocities in x and y directions respectively, γ_b is the friction coefficient (0.0026), L is the eddy viscosity coefficient (6 x 10^5 cgs) in the horizontal direction, and U and V are the average velocities. The space co-ordinate system is shown in Fig. 4-8.

v) Compoutation of Water Quality

The unsteady two-dimensional dispersion equation is used for the computation. The method of numerical computation was discussed in Section (4-3-1).

a) Dispersion Coefficients

The dispersion coefficients may be determined on a trial basis so that the computation with respect to chloride ion concentration produces a distribution which coincide the best with the measured distribution. The mesh size used in this computation was 2 km both for Δx and Δy, and Δt was 15 minutes. The dispersion coefficients examined were of the Kolomogoroff and Elder types. The dispersion coefficient of the Kolomogoroff type is expressed as follows by taking the water depth as a scale of dispersion.

$$D_x = D_y = \alpha' H^{4/3} \quad \ldots\ldots \quad (4.15)$$

The dispersion coefficient of the Elder type is non-isotropic and a function of the depth and the friction velocity, and the coefficient, for example in the x direction is given as:

$$D_x = \alpha (0.265\, V_x + 0.003\, V_y)\, H \quad \ldots\ldots \quad (4.16)$$

by assuming the relation between the friction velocity (U*) and the average velocity (V) as:

$$U^* = (0.002)^{1/2} V$$

Several trial runs of computation were performed to find out the value of α' in Eq. 4.15 or α in Eq. 4.16, which would give the best computational results. Giving the observed distribution of chloride ion as the initial condition, the computation was conducted up to 500 time steps (10 tidal cycles), and the discrepancy from the initial distribution was examined. The results of the computation indicated that the calculated distributions of chloride ion were practically the same as the measured distribution for all runs, and the difference in the magnitude of the dispersion coefficient within the examined range did not have much effect. This may be because the gradient of the chloride ion concentration in the bay is relatively small.

b) COD Reduction Coefficient

The COD reduction coefficient (K_c) is also determined by the comparison of the calculated distributions under various K_c values with the observed distribution. The boundary condition at the month of the Bay in these computations was set to be 1.5 ppm of COD from the actual measurement. At the boundaries with six major rivers flowing into the Bay, the measured COD was given as boundary conditions. For the boundaries other than those with the open sea and the six major rivers, the velocity and the dispersion coefficient were set to be zero and corresponding COD load was added. Three computor runs were carried out with the COD reduction coefficients of 0.2, 0.1 and 0.05 (in 1/d, e base) respectively, and the calculated distributions after 500 time steps (10 tidal cycles) were compared with the observed distribution. According to the results of the computation, the computor run with the COD reduction coefficient of 0.05 gave the most satisfactory results on the whole. However, there was a trend that the computed values were larger than the measured COD in the coastal areas, indicating that the COD reduction coefficient might vary with space.

As the next stage of this project, the plan to improve the water quality of Tokyo Bay, including the sewerage program and industrial wastes control, will be evaluated taking into account of further development of this area. The whole project is to be completed by the end of 1973 fiscal year. The complete result will be presented to the next meeting of the U.S.-Japan Conference on Sewage Treatment Technology.

4.4 Aspects of Future Study

4.4.1 Study on the effect of bottom deposits on the bed of rivers, lakes and seas, upon water pollution and method of dredging thereof, as well as the disposal of dredged deposits:

Bottom deposits in certain rivers, lakes and seas contain considerable amount of organic matters, toxic substances (heavy metal, chlorinated organic compounds such as PCB and so on). The behaviour of these deposits in the water and their effect on the water quality are not yet made clear. The removal of these deposits by dredging is desirable in many cases, and studies are required on the method or dredging and the disposal of dredged deposits.

4.4.2 Study on the improvement in the method of water quality simulation and its accuracy:

In recent years method of water quality simulation has progressed considerably. However, method of simulation with respect to the accumulation of organic matter and nutrients in lakes are not fully developed. Furthermore, in estuaries and seas, computation is possible only when the pollutants are mixed uniformly in the vertical direction. The water quality in lakes, estuaries and seas is usually the worst in summer when the density stratification is significant. Therefore, the development of the simulation method for the stratified body of water is being required.

4.4.3 Basic study on self-purification capacity of rivers and accumulation of toxic substances in aquatic organisms:

The over-all decay of organic pollutants in rivers have been measured widely. However, the decay of a particular organic pollutant in the river is not necessarily clear. Moreover, considerable amount of toxic substances (heavy metal, etc.) discharged into rivers may be accumlated in aquatic organisms, but the quantitative evaluation is not yet made. The effects of accumlation upon aquatic organism are not known too.

4.4.4 Basic study on eutrophication of lakes and seas

Many studies have been carried out already on the eutrophication phenomenon of lakes and seas, but there still remain many unknown factors such as the concentration of nutrients, carbonacious compounds and other elements, and the interrelationship between these substances. The role of rare elements is not know too.

Table 4-1 Present Situations of the Kasumigaura Lakes and their Basins

Items / Name of Lakes	Lakes		Basin					
	Area (Km^2)	Volume $(10^6 m^3)$	Area (Km^2)	Population $(X10^3)$	Animals		Irrigation Field (1) (Km^2)	Forest (Km^2)
					Hog $(X10^3)$	Cattle $(X10^3)$		
Nishiura	171.0	663	1,426	654	251.8		402.0	368.7
Kitaura	34.4	203	360	114.7	76.0		59.7	110.3
Sotogasakaura	6.2	7.5	163	132.3	11.5		57.1	19.7

(1) Irrigation Field is contains only peddy field.

Table 4-2 Present Average Water Quality of the Kasumigaura Lakes

(mg/ℓ)

Date	Items / Lakes	BOD	COD(1)	TOC	Dissolved TOC	Total Nitrogen	Dissolved Total Nitrogen	Ammoiacal Nitrogen
Feb. 29	Nishiura	2.2	5.8	3.9	2.5	1.95	1.85	0.07
	Kitaura	2.2	5.5	3.8	2.5	1.59	1.34	0.11
May 19	Nishiura	2.5	7.8	3.0	2.6	0.86	0.74	0.03
	Kitaura	2.7	9.7	3.7	2.1	0.99	0.82	0.03

Date	Items / Lakes	Nitrite Nitrogen	Nitrate Nitorgen	Total Phosphorous	Dissolved Total Phosphorous	Ortho-Phosphate (2)	Suspened Solids
Feb. 29	Nishiura	0.00	0.98	0.04	0.03	0.002	15
	Kitaura	0.00	0.75	0.05	0.03	0.002	10
May 19	Nishiura	0.00	0.14	0.06	0.04	0.014	10
	Kitaura	0.00	0.15	0.08	0.04	0.010	19

(1) Permangamate COD by Acidified Method

(2) Ortho-Phosphate as P

Table 4-3 Pollution Loads in Kasumigaura Basins

(ton/day)

Items / Basins / Sources	BOD			Nitrogen			Phosphorus		
	Nishiura Lake	Kitaura Lake	Sotogasaka-ura Lake	Nishiura Lake	Kitaura Lake	Sotogasaka-ura Lake	Nishiura Lake	Kutaura Lake	Sotogasaka-ura Lake
Domestic Sewage	28.77	5.05	5.83	7.84	1.37	1.60	0.911	0.163	0.186
	21.31	3.96	4.45	3.58	0.65	0.75	0.745	0.121	0.148
Industrial Wastes	20.98	2.66	0.12	1.78	0.43	0.02	0.235	0.083	0.000
	12.40	0.37	0.12	1.24	0.04	0.02	0.185	0.005	0.000
Livestock Raising	63.90	20.00	2.83	16.27	5.24	0.70	7.350	2.270	0.350
	30.88	9.53	1.38	9.70	3.03	0.43	3.687	1.129	0.167
Irrigation Fields	78.80	11.71	11.19	45.26	6.73	6.43	3.520	0.520	0.500
	35.46	5.27	5.04	20.37	3.03	2.89	0.176	0.026	0.025
Forest	-	-	-	0.70	0.21	0.04	0.020	0.010	0.000
	-	-	-	0.70	0.21	0.04	0.020	0.010	0.000
Total	192.45	39.42	19.97	71.85	13.98	8.79	12.036	3.046	1.016
	100.05	19.13	10.99	35.59	6.96	4.13	4.813	1.291	0.340

Remarks: Upper figure in each column is total load produced in the basin. The lower figure is the load which is actually discharged into the Lake.

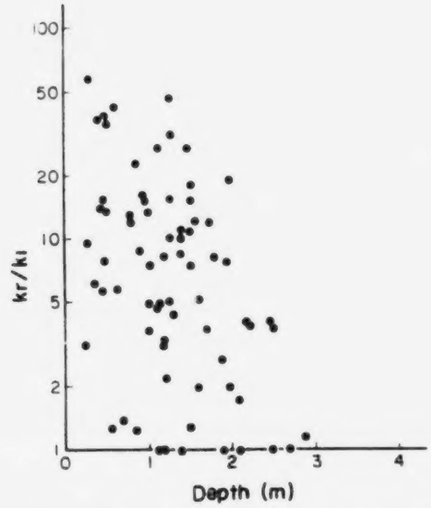

Fig. 4-1 Kr/K₁ Versus Average Depth in Streams

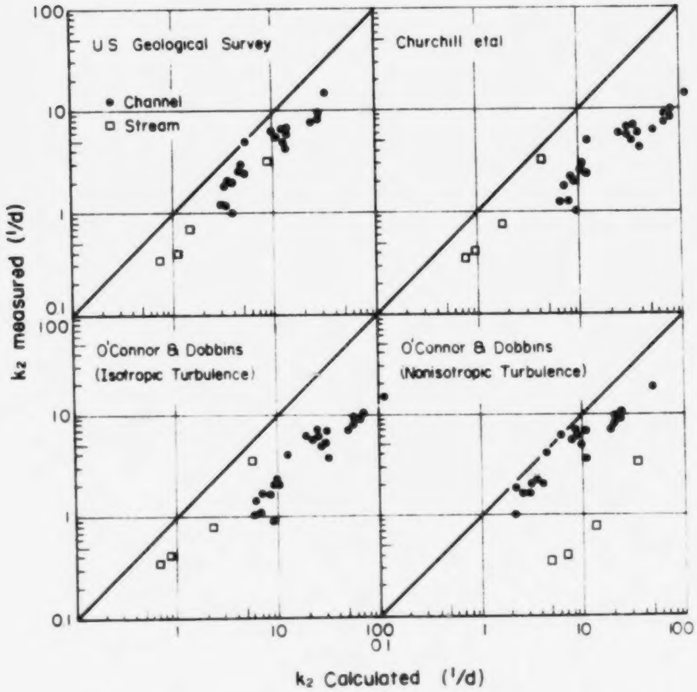

Fig. 4-2 Comparison Between Measured Values and Calculated Values by Existing Formula

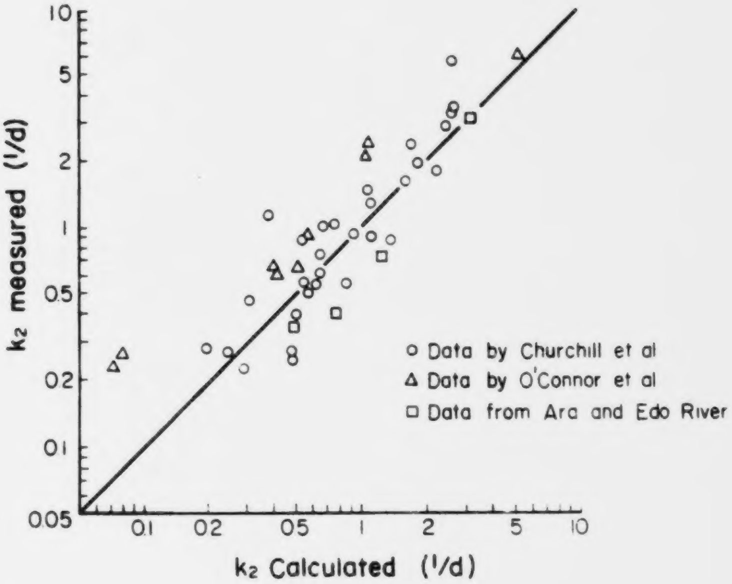

Fig. 4-3 Comparison Between Measured Values in Stream and Calculated Values by Proposed Formula

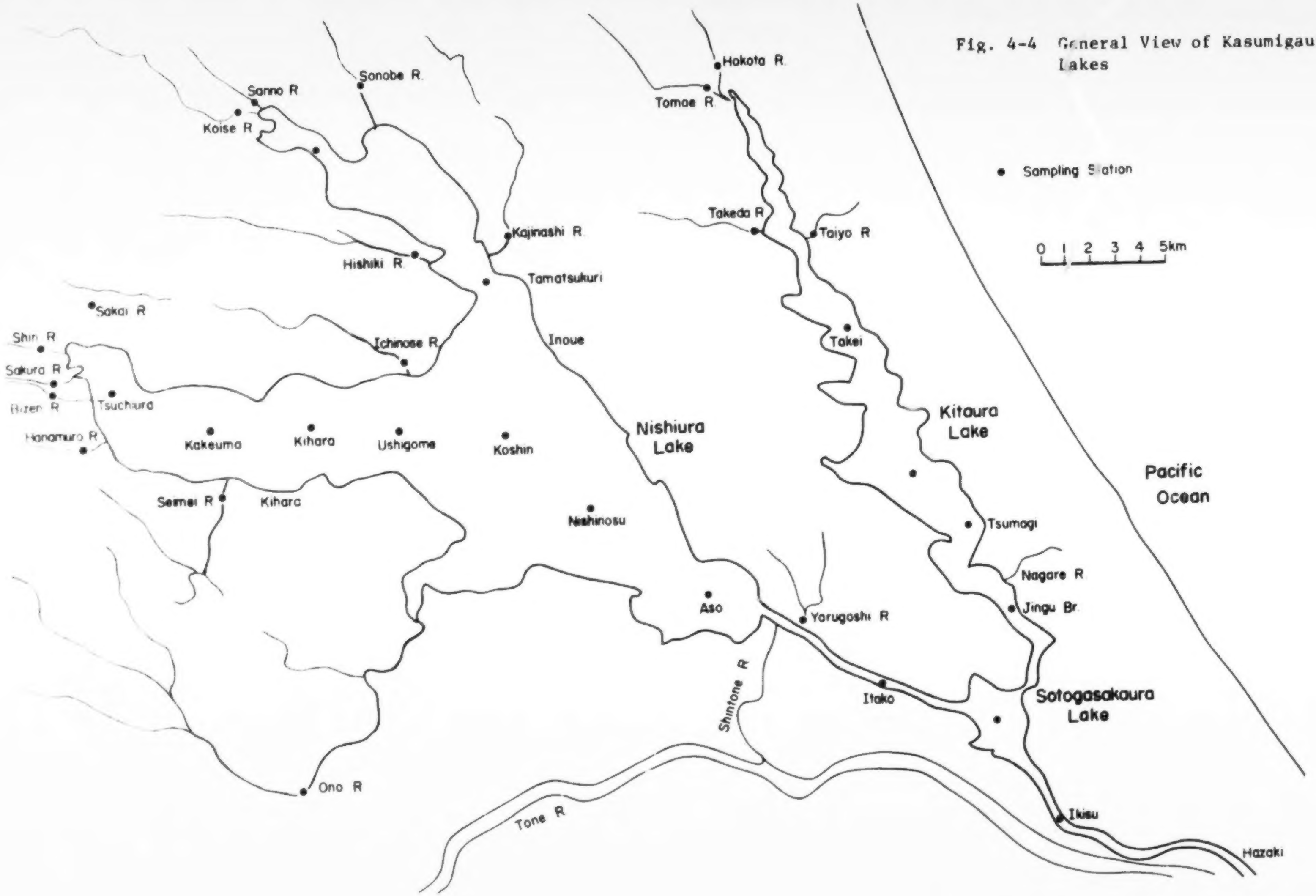

Fig. 4-4 General View of Kasumigaura Lakes

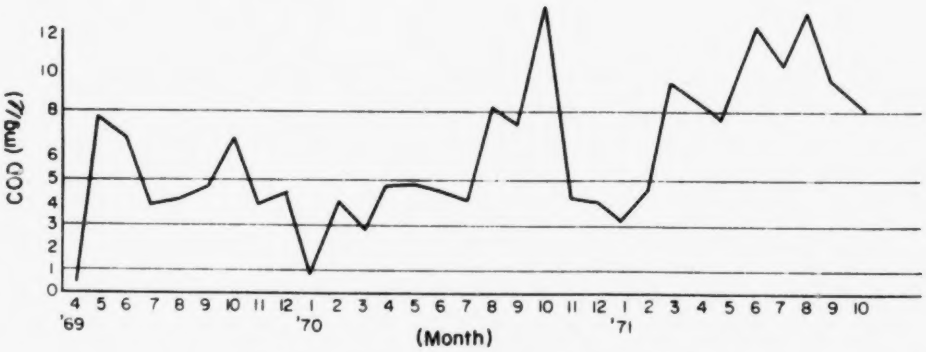

Fig. 4-5 Variation of COD at the Intake for Water Supply

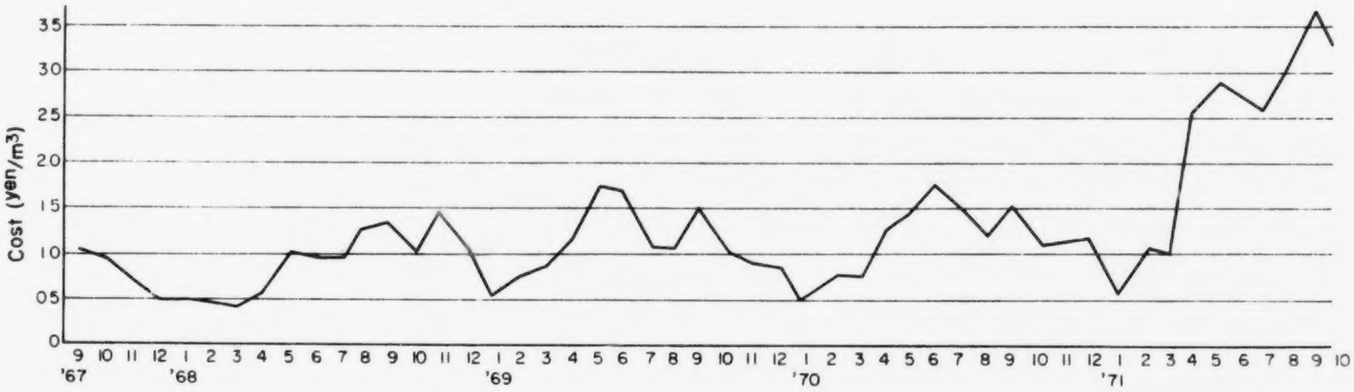

Fig. 4-6 Variation of Chemical Doseing Cost for Domestic Water Supply

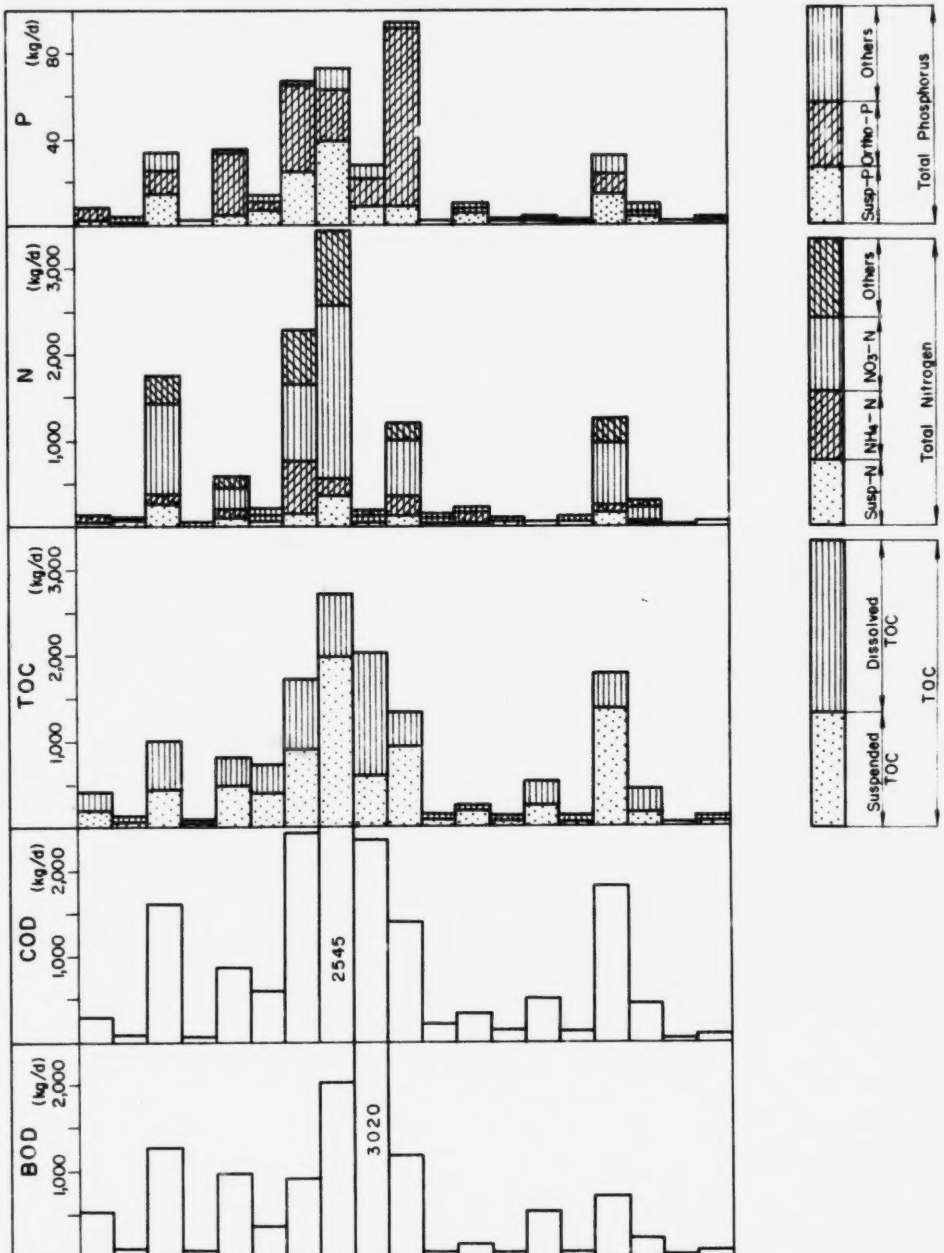

Fig. 4-7 Organic and Nutrient Loads to Kasumigaura Lakes

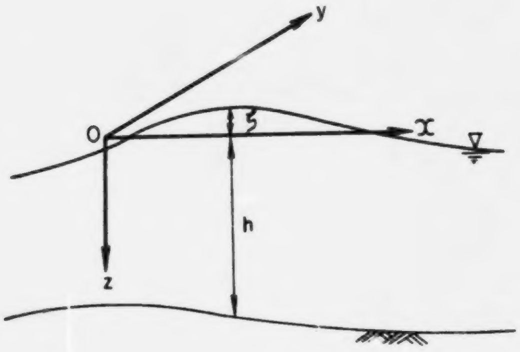

Fig. 4-8 Co-ordinates for Calculation

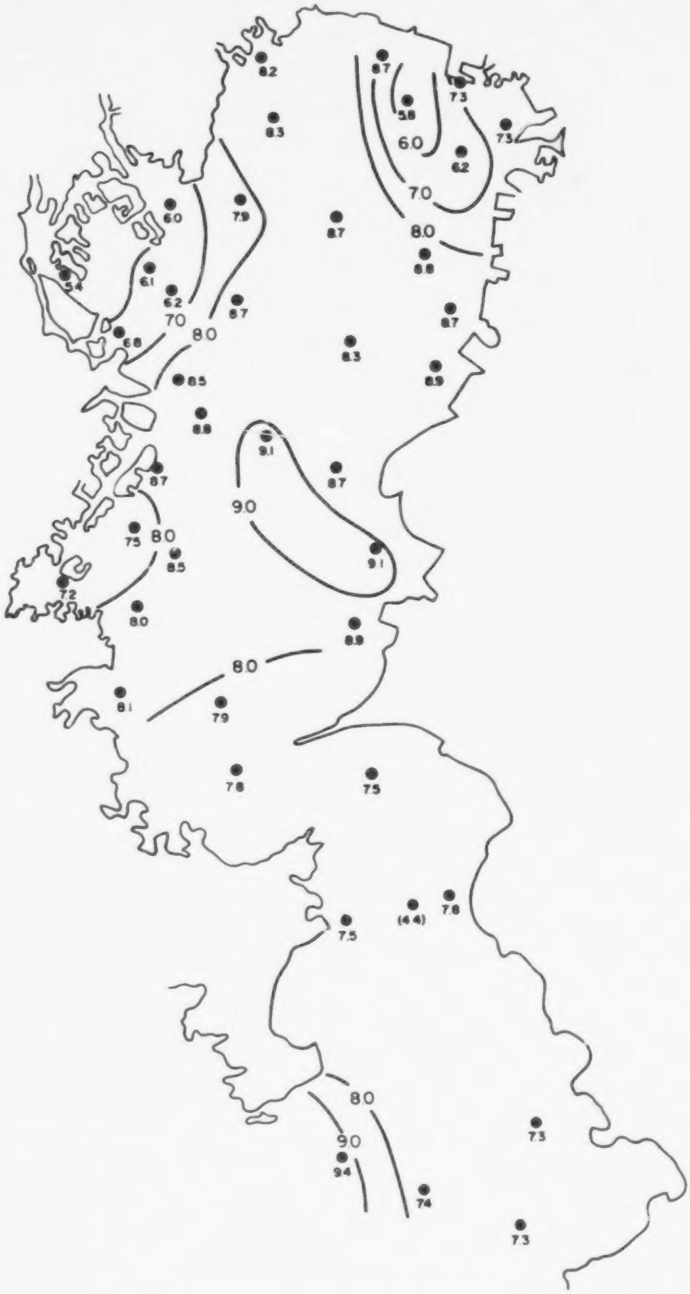

Fig. 4-9 DO Distribution of Upper Layer in Tokvo Bay (mg/ℓ)

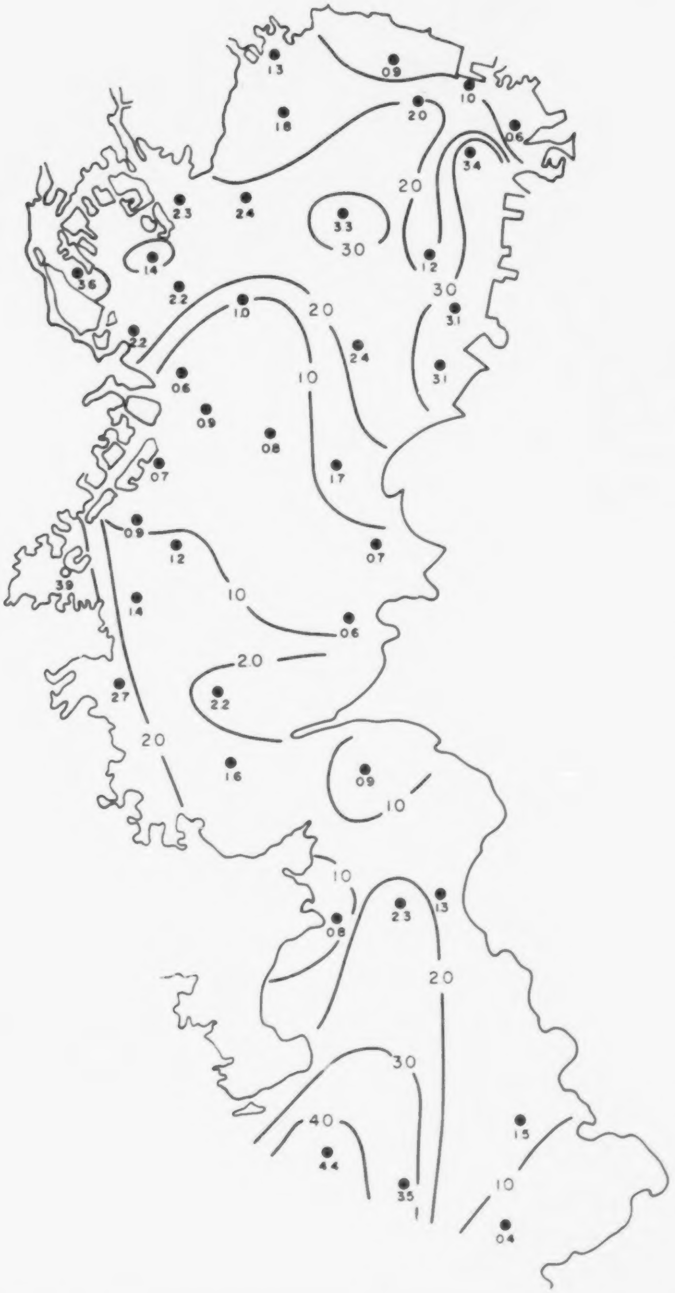

Fig. 4-10 BOD Distribution of Upper Layer in Tokyo Bay (mg/ℓ)

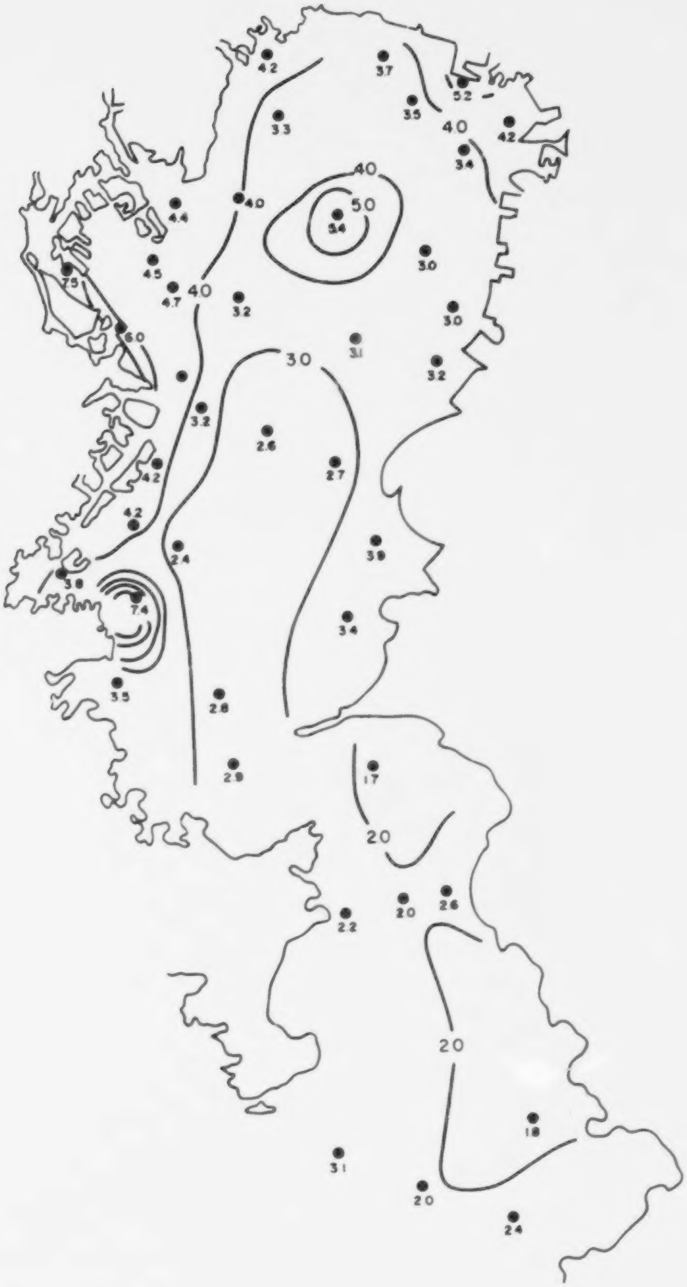

Fig. 4-11 COD Distribution of Upper Layer in Tokyo Bay

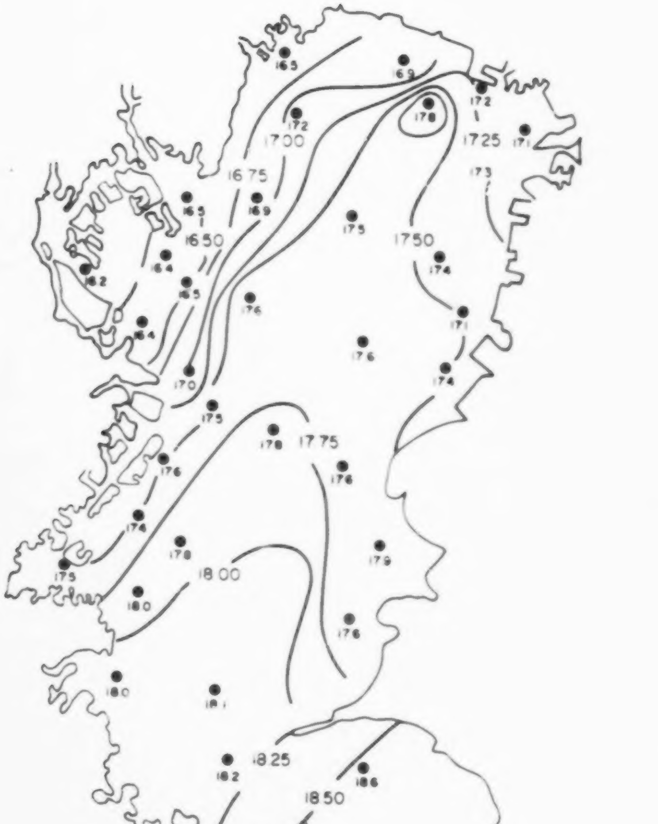

Fig. 4-12 Chloride Distribution of Upper Layer in Tokvo Bay (‰)

5. Studies on Advanced Waste Treatment

5.1 Laboratory Tests on Advanced Waste Treatment

The laboratory tests on advanced waste treatment being carried out by the Public Works Research Institute are mainly on lime clarification. Tests of this kind have been carried out in the United States in great extent, and the results of these studies are very helpful for us.

Japan is not rich in mineral resources, but reserves of lime stone are relatively large. It is reported that reserves of lime stone containing calcium more than 54% as CaO (more than 96.5% as $CaCO_3$) are about 40 billion tons, of which 26.6 billion tons are quarrable reserves. In addition, line stone is distributed almost all over Japan. Therefor, the cost of lime as a coagulant is relatively cheap, and lime clarification is considered to be one of the most suitable advanced waste treatment processes in Japan.

The average concentrations of total phosphorus and total nitrogen in domestic sewage flowing into the sewage treatment plants are 4.2 mg/l and 26.6 mg/l, respectively. These concentrations will increase greatly in the near future.

The removal of total phosphorus in the sewage by primary and secondary treatment is usually within the range of 20 - 30%. In the case of nitrogen, though the forms of nitrogen change during the treatment by decomposition, nitrification and so on, the removal is generally 20 - 40% as total nitrogen.

The relationship between pH and remaining phosphorus concentration obtained by laboratory tests of lime clarification is shown, for total phosphorus, dissolved total phosphate, ortho-phosphate, in Fig. - 5.1, 5.2, 5.3 and 5.4, respectively. Samples for total phosphorus and ortho-phosphate (Figs. - 5.1 and 5.3) were taken after 30 minutes sedimentation following the floculation. It may be concluded from Figs.-5.1 and 5.2 that, when pH is raised up to 10.5 or more, total phosphate concentration in the supernatant becomes 0.5 mg/l or less, regardless of sewage tested, that is, raw sewage, primary effluent or secondary effluent. Similarly, in the case of ortho-phosphate shown in Fig. -5.3 and Fig. -5.4, the ortho-phosphate concentration after lime clarification is made to 0.1 mg/l or less when pH is raised up to 10.5 or more. In order to examine the effect of pH further, the data show in Fig. -5.1 were classified into three groups according to pH value, that is, pH of 10.5 - 11.0, 11.0 - 11.5 and more than 11.5, and the ratios of the numbers of data of which total phosphorus concentrations are in the ranges of ≦ 0.5 mg/l, ≦ 0.3 mg/l, ≦ 0.2 mg/l and ≦ 0.1 mg/l, respectively, to the total number of data in each group are calculated. The result is shown in Fig. -5.5. According to this figure, even when pH is more than 10. 5 the total phosphate concentration in the supernatant decreases with the rise in pH, and when pH is 11. 0 - 11. 5, the phosphorus concentration of 85% data is 0. 5 mg/l or less, 73% is 0. 3 mg/l or less, and 50% is 0. 1 mg/l or less.

The lime dosage to raise pH up to 11. 0 is different, as shown in Table-5. 1, depending on the buffer capacity of sewage. As index of this buffer capacity alkalinity has been used. As shown in Fig. -5. 6, the result of this experiment shows the same trend as that reported by Mulberger et al.

The role of magnesium in the lime clarification process was studied by Stanberg et al. The concentration of magnesium in sewage in Japan is 5 - 50 mg/l. A laboratory experiment has been made to know the effect of magnesium on the removal of phosphate. In this experiment, ortho-phosphoric and meta-hosphoric acids were used as the source of phosphorus. A part of the result is shown in Fig. -5. 7 and 5. 8. As shown in Fig. -5. 7, removal of meta-phosphate is affected by the presence of magnesium in the water, whereas, removal of ortho-phosphate is not affected. Fig. -5. 8 shows the relationship between the magnesium removal vs. phosphorus (P) and dissolved phosphorus (P-D) in the supernatant, obtained from jar tests with the constant initial concentration of phosphorus and six different initial concentrations of magnesium. According to Fig. -5. 8, the removal of ortho-phosphate again is not dependent on magnesium concentration, but the removal of meta-phosphate increases considerably with the increase in the magnesium removal. In addition, there has been found a deffinite correlation between the concentrations of insoluble Ca in the supernatant and insoluble phosphorus. And the concentration of insoluble Ca in the superatant decreases with the increase in Mg removal as shown in Fig. -5. 9. Therefore, it may be concluded that the settling of insoluble Ca containing metaphosphate is accelerated by the presence of $Mg(OH)_2$ and the removal of meta-phosphate increases with the increase in Mg removal.

It has been proved by the X-ray diffraction analysis that ortho-phosphate is changed in the lime clarification process, into calcium hydroxylapatite and settles. Roughly half of phosphorus in raw sewage is in the form of poly-phosphate. According to the laboratory test of lime clarification of sodium tripoly-phosphate solution, a part of tripoly-phosphate is hydrated to ortho-phosphate during the lime coagulation process. In fact, the existance of calsium hydroxylapatite in the sludge was proved by infra-red absorption analysis.

The result of analysis of the sludge from lime clarification is as shown in Fig. -5. 10. Since the sludge from lime clarification of secondary effluent has much calcium contents, it is effective to incinerate the sludge and reuse it as lime. However, in the case of the sludge from lime clarification of raw sewage, it contains a great quantity of SiO_2 and oxydized metals in the form of R_2O_3, and thoroughgoing survey shall have to be made in re-using it as lime.

5.2 Experiment at Yokosuka Pilot Plant

As mentioned on the ocasion of First U. S. -Japan Conference on Sewage Treatment Technology held in Tokyo, a pilot plant was constructed in the Shimomachi Sewage Treatment Plant in Yokosuka City, near Tokyo. This plant has been continuously in operation since May this year.

This pilot plant is, as explained in Fig. -11, consisted of lime clarification, ammonia stripping, recarbonation, and filtration. In order to make the operation flexible, multiple facilities are provided such as 2 flash mixers, 3 flocculation tanks, one return sludge line, 2 recarbonation tanks, 2 settling tanks for calcium carbonate, and 2 dual medea filters. The design flow is 9 m^3/hr for lime clarification and 2 m^3/hr for other processes. Principal dimensions of each facility are shown in Table-5.2. Sewage to be fed into this plant may be raw sewage, primary effluent or secondary effluent, but for the time being, experiments will be performed as to the secondary effluent.

Collection of operation data has continuously been carried out since May 16, and those until July 24 are as shown in Table-5.3. From May 16 to June 7 only lime clarification process was operated and since June 12, the whole system has been working.

The ammonia concentration in the effluent from the Shimomachi Sewage Treatment Plant, Yokosuka City is extremely low at present. Thus, the removal of ammoniacal nitrogen by the pilot plant is low. However, in near future the supernatant liquor from sludge digestion tanks is to be added to raw sewage, and the ammonia concentration in the secondary effluent will be increased, allowing to perform experiments on ammonia stripping under normal conditions. The removal of phosphorus by lime clarification process is very high as is in the case of laboratory experiment. The removal of phosphorus and suspended solids is 90% or more (as a whole system including filtration). Removal of COD and BOD is, as was expected, 20 - 50%.

This pilot plant has been operated for several months only, but has already troubles of the formation of scale caused by calcium carbonate. This scale, as shown in Table-5.4, is the mixture of aragonite and calcite, and is in granular form near the water surface, and in plate form on the wall. The scale in plate form is very hard and its growth on the wall is quick, particularly in laminar flow. At present, hydrochloric acid is used to remove the scale attached on the inside wall of the pipe, but the use of hydrochloric acid in the actual facility is impossible. Therefore, the study is being required on how to remove the scale and to prevent the formation of the scale.

5.3 Aspects of Future Study

5.3.1 Study on the improvement in the water quality of the effluent from lime clarification system:

As stated in preceding section 5.2.1, Yokosuka Pilot Plant is consisted of lime clarification, ammonia stripping, recarbonation, and filtration. In order to obtain the effluent with higher water quality and to study on the processes for it, the pilot plant will be expanded to include granular activated carbon adsorption process and reverse osmoses. Activated carbon will be regenerated by a small scale furnace and will be reused with the addition of make-up carbon. As for lime clarifier, it has been found from the experiment so far that the overflow rate must be considerably small. Therefore, another clarifier will be installed and studies will be carried out to improve the setting efficiency by the use of polymer or the use of tube settlers.

5.3.2 Study on the treatment of lime sludge and the reuse of reclaimed lime:

Since, in lime treatment, the reuse of sludge from lime clarifier and calcium carbonate clarifier is required for lowering of treatment cost, study will be made on the sludge treatment and re-use of reclaimed lime by laboratory experiment and pilot scale study at Yokosuka Pilot Plant. For this purpose, sludge thickening tank, dewatering process and sludge furnace, etc., will be additionally equipped with Yokosuka Pilot Plant.

5.3.3 Study on tertiary treatment processes mainly for organic matter removal:

Enforcement of water quality standard and preservation of water resources, especially for water supply, often require higher removal of organic matter and related pollutants. In order to study on the processes related to the above requirement, a pilot plant will be constructed in the Toba Sewage Treatment Plant in Kyoto City, which will be consisted of filtration, activated carbon absorption process with regeneration device, break point chlorination process and so on. Of the above processes, 3 down flow type filters (1.2 m^2/filter area per each filter) are scheduled to be completed by February of 1973. The filter media of each filter will be sand only, anthracite-sand and anthracite-sand-garnet, respectively, and comparative tests will be performed. In addition, an upflow type filter will also be constructed, and the characteristics will be compared. Granular activated carbon absorption tanks will be of gravity type, and 6 tanks are scheduled to be installed.

5.3.4 Study on the removal of phosphate in activated sludge treatment process

Since the activated sludge process is most commonly adopted in treatment plants in Japan, experiment of removing phosphate by addition of ferric or aluminium salts to the aeration tank will be carried out making use of one set of aeration tank and final sedimentation tank of an existing sewage treatment plant.

Table 5-1 Lime Dosage for pH 11.0

[mg L^{-1} as Ca $(OH)_2$]

Item	Raw Sewage with Digestor Supernatant	Raw Sewage	Primary Sedimentation Tank Effluent	Secondary Sedimentation Tank Effluent
Range	172 ∿ 396	135 ∿ 450	146 ∿ 401	146 ∿ 296
Average	293	323	255	234

Table 5-2 Pilot Plant Characteristics

Process	Apparatus	No.	Size (m)
Lime Precipitation	Receiving Tank	1	0.75W x 1.5L x 1.5H, Overflow Weir Waste Adjustment Valve
	Measuring Tank	1	0.60W x 1.2L x 0.7H 60 degree Triangle Weir
	Flush Mixer Tank	2	0.75ϕ x 1.3H Effective Vol. 0.45 m^3 each, Mixer 0.4KW, Variable revolution max. 360 rpm
	Flocculation Tank	3	1.4ϕ x 1.3H Effective Vol. 1.5 m^3 each, Mixer 0.4KW, Fixed revolution 5 rpm
	Lime Tank	2	1.0ϕ x 1.5H Mixer 2.2KW
	Lime Pump	1	Diaphram Type, 0.3 ∿ 1.2 litre min^{-1} pipe dia. 25 mm, 0.2KW
	Settling Tank	1	2.4ϕ x 3.3H, Sludge Collector 0.75KW
	Sludge Storage Tank	1	0.8ϕ x 2.3H, Mixer 0.4KW
	Sludge Return Pump	1	Diaphram Type, 0 ∿ 50 litre min^{-1} pipe dia. 50 mm, 1.5KW
	Effluent Holding Tank	1	1.2ϕ x 1.4H
Ammonia Stripping	Influent Pump	1	Centrifugal Type 2.2KW Total Heed 20m, 0.14 m^3 min^{-1}
	Stripping Tower	1	1.2W x 1.8L x 7.5H, Fan 3.7KW, 60 ∿ 150 m^3 min^{-1} 50 mm Aq Packed Material 0.9W x 1.18L x 1.25H 6 stage Packed Wood Japanese Cypress 40 mmW x 1.18L x 10mmH Number 2,880
	Measuring Tank	1	0.6W x 1.0L x 0.6H 15 degree Triangle Weir
	Effluent Holding Tank	1	1.0W x 1.0L x 0.7H
Recarbonation	Influent Pump	1	Centrifugal Type 1.5KW Total Head 13 m, 0.08 m^3 min^{-1}
	Measuring Tank	1	0.4W x 1.04L x 0.6H 15 degree Triangle Weir
	Recarbonation	2	0.5ϕ x 3.8H, Effective Vol. 0.7 m^3 each
	CO_2 Bomb	3	50 kg each
	Blower	1	0.25 m^3 min^{-1}, 0.5 kg cm^{-2}
	$CaCO_3$ Settling Tank	2	1.5ϕ x 4.6H
Filter	Rapid Sand Filter	2	0.7ϕ x 2.8H Area 0.38 m^2 each No. 1 Anthracite Eff. Size 0.8 mm Depth 0.3 Sand Eff. Size 0.45 mm Depth 0.3 No. 2 Anthracite Eff. Size 1.2 mm Depth 0.3 Sand Eff. Size 0.55 mm Depth 0.3
	Back Washing Pump	1	Centrifugal Type 2.2KW Total Head 15 m, 0.4 m^3 min^{-1}
	Measuring Tank	2	0.4W x 1.05L x 0.6H 15 degree Triangle Weir
	Effluent Holding Tank	1	1.7W x 2.0L x 2.0H

Table 5-3A Pilot Plant Study Results
Operation

Period	Process	Item	Value
May 16 ∿ June 7 Run 1	Lime Precipitation	Flash Mixer Tank	
		Detention Time	10 min.
		Revolution	100 rpm
		No. of Tanks	2
		Flocculation Tank	
		Detention Time	30 min.
		Revolution	5 rpm
		No. of Tanks	3
		Settling Tank	
		Detention Time	1.7 hr
		Over Flow Rate	35 $m^3\ m^{-2}\ d^{-1}$
June 12∿ June 30 Run 2	Lime Precipitation		Same as above
	Ammonia Stripping	Flow Rate	67.8 $m^3\ m^{-2}\ d^{-1}$
		Air Volume	150 $m^3\ min^{-1}$
		Waste/Air Rate	3,000
	Recarbonation	First Stage Recarbonation Tank	
		Detention Time	16.5 min.
		Waste/CO_2 Ratio	0
		Waste/Air Ratio	8.3
		$CaCO_3$ Setting Tank	
		Detention Time	4.7 hr
		Overflow Ratio	16.9 $m^3\ m^{-2}\ d^{-1}$
		Second Stage Recarbonation Tank	
		Detention Time	16.5 min.
		Waste/CO_2 Ratio	41.7
		Waste/Air Ratio	4.6
	Rapid Sand Filter	Filter	No. 1 & No. 2
		Filter Velocity	60 m/d
		Filtered/Washing	109
July 4 ∿ July 24 Run 3	Lime Precipitation		Same as above
	Ammonia Stripping	Flow Rate	204 $m^3\ m^{-2}\ d^{-1}$
		Air Volume	150 $m^3\ min^{-1}$
		Waste/Air Ratio	1,000
	Recarbonation	First Stage Recarbonation Tank	
		Detention Time	7 min.
		Waste/CO_2 Ratio	100
		Waste/Air Ratio	11.1
		$CaCO_3$ Settling Tank	
		Detention Time	0.9 hr
		Overflow Ratio	85.2 $m^3\ m^{-2}\ d^{-1}$
		Second Stage Recarbonation Tank	
		Detention Time	7 min.
		Waste/CO_2 Ratio	50
		Waste/Air Ratio	5.6
	Rapid Sand Filter	Filter	No. 1 or No. 2
		Filter Velocity	343 $m^3\ m^{-2}\ d^{-1}$
		Filtered/Washing	877

Table 5-3B Pilot Plant Study Results Average Removals

Run	Item	Influent	Lime Preciptation		Ammonia Stripping		Recarbonation		Rapid Sand Filter	
		mg/L	mg/L	%	mg/L	%	mg/L	%	mg/L	%
1 *	pH	7.40	10.6	-	-	-	-	-	-	-
	Turbidity	44.9	43.0	4.2	-	-	-	-	-	-
	Sus. Solids	82.5	66.4	19.5	-	-	-	-	-	-
	COD-Mn	32.9	17.8	45.9	-	-	-	-	-	-
	COD-Cr	118.0	78.3	33.6	-	-	-	-	-	-
	BOD	82.2	28.0	66.0	-	-	-	-	-	-
	TOC	41.5	18.0	56.7	-	-	-	-	-	-
	Total-P	2.59	0.25	93.5	-	-	-	-	-	-
	Ortho-P	1.30	0.11	91.8	-	-	-	-	-	-
	Total-N	16.0	9.37	41.4	-	-	-	-	-	-
	NH_4-N	5.12	2.78	45.7	-	-	-	-	-	-
	NO_2-N	0.04	0.18	-77.8	-	-	-	-	-	-
	NO_3-N	0.07	0.15	-114.1	-	-	-	-	-	-
	Alkalinity	72.3	-	-	-	-	-	-	-	-
2 **	pH	7.10	10.0	-	9.38	-	8.83	-	7.49	-
	Turbidity	5.6	51.4	-	7.1	-	3.3	41.1	0.67	88.0
	Sus. Solids	5.7	89.7	-	13.5	-	6.0	-	0.0	100
	COD-Mn	5.9	3.5	40.7	4.2	28.8	5.9	0	4.0	23.7
	COD-Cr	29.7	14.8	50.2	21.3	28.3	28.7	0	14.5	51.2
	BOD	7.2	3.9	45.9	3.5	51.5	6.8	5.6	3.6	50.0
	TOC	20.7	16.8	19.8	13.1	36.7	13.4	35.3	15.8	23.7
	Total-P	1.23	0.46	62.6	0.13	89.5	0.11	91.0	0.11	91.0
	Ortho-P	1.02	0.43	57.8	0.06	94.1	0.02	98.0	0.04	96.0
	Total-N	5.05	5.47	-7.9	3.79	25.0	-	-	4.52	10.5
	NH_4-N	0.64	0.52	18.8	0.36	43.8	-	-	0.18	71.9
	NO_2-N	0.24	0.16	33.3	0.31	-22.6	-	-	0.37	-35.2
	NO_3-N	2.63	3.64	-27.8	2.16	17.9	-	-	2.71	-3.4
	Alkalinity	83.8	-	-	-	-	-	-	-	-
3 **	pH	7.04	9.96	-	9.35	-	8.47	-	7.32	-
	Turbidity	10.1	114.1	-	19.0	-	4.7	53.5	0.16	93.0
	Sus. Solids	14.1	163.8		26.4	-	5.2	63.0	0.0	100
	COD-Mn	5.8	3.4	41.4	3.9	32.8	5.8	0	3.8	34.5
	COD-Cr	13.8	15.7	-	18.7	-	13.1	5.1	10.5	23.9
	BOD	7.1	4.1	42.3	4.9	31.0	9.2	-	5.0	29.6
	TOC	17.2	18.1	-	15.6	9.3	16.5	4.1	21.9	-
	Total-P	1.10	0.72	33.6	0.15	86.4	0.12	89.1	0.07	93.5
	Ortho-P	1.03	0.03	97.0	0.04	96.0	0.01	99.0	0.02	98.0
	Total-N	6.90	6.73	2.5	5.88	14.8	-	-	5.74	16.8
	NH_4-N	0.25	0.28	-11.7	0.16	36.0	-	-	0.20	20.0
	NO_2-N	0.15	0.18	-16.6	0.36	-58.4	-	-	0.23	-34.8
	NO_3-N	2.89	3.29	- 1.2	2.80	2.7	-	-	2.98	-3.0
	Alkalinity	101.1	-	-	-	-	-	-	-	-

* Influent of Run 1 is raw sewage.

** Influent of Runs 2 and 3 are effluent of final settling tank.

Table 5-4 Results of X-ray Diffraction Analysis of $CaCO_3$ Scales in Each Apparatus

Apparatus	Position	Form of Scales	Hardness	Form and Relative Quantity
Sludge Return Pipe	Inner Wall	Gel	-	Calcite - Much $Ca(OH)_2$ - Medium
Flush Mixer Tank	Surface	Particles	Soft	Calcite - Much Aragonite - Little
Flocculation Tank	Surface	Particles Plate	Soft	Aragonite - Much Calcite - Medium
Settling Tank	Inner Wall	Plate	Hard	Calcite - Much Aragonite - Medium
Holding Tank	pH Electrode	Plate	Hard	Calcite - Much Aragonite - Little

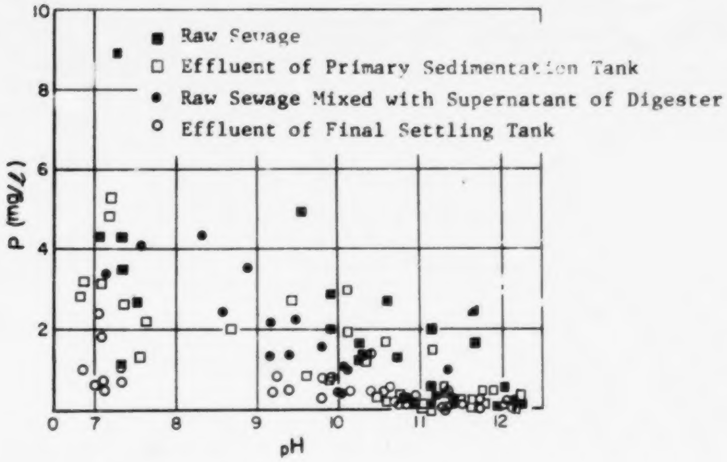

Fig. 5-1 Remaining Total Phosphorus vs.
Adjusted pH by $Ca(OH)_2$
(After 30 min. settling)

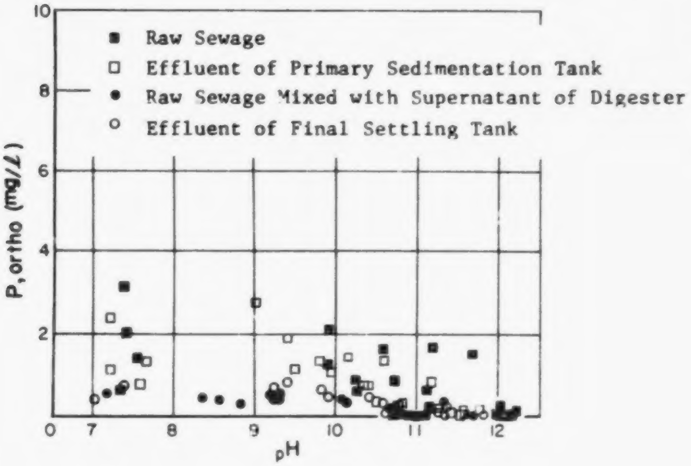

Fig. 5-2 Remaining Ortho Phosphate vs.
Adjusted pH by $Ca(OH)_2$
(After 30 min. settling)

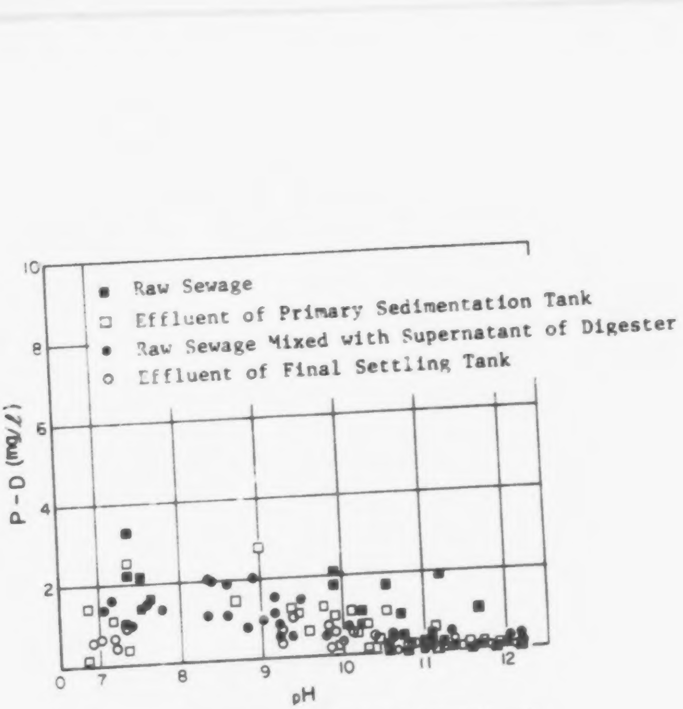

Fig. 5-3 Remaining Dissolved Phosphorus vs. Adjusted pH by $Ca(OH)_2$ (After 30 min. settling)

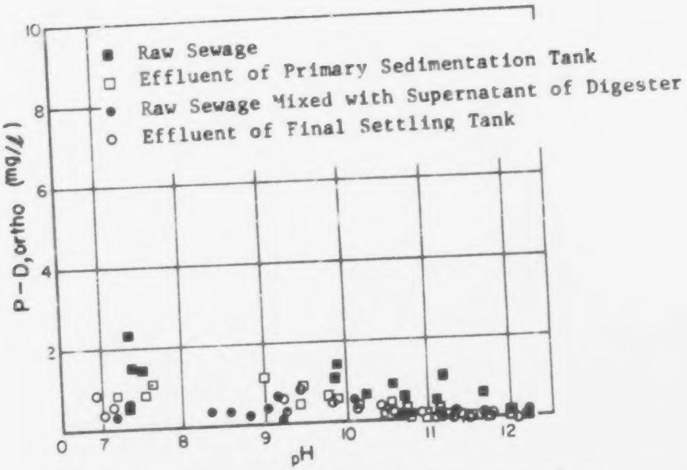

Fig. 5-4 Remaining Dissolved Ortho Phosphate Adjusted pH by $Ca(OH)_2$ (After 30 min. settling)

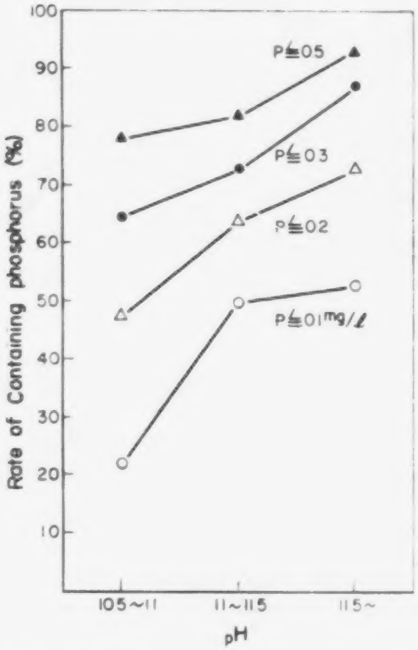

Fig. 5-5 pH vs. Remaining Phosphorus Concentration (Result of Jar Test)

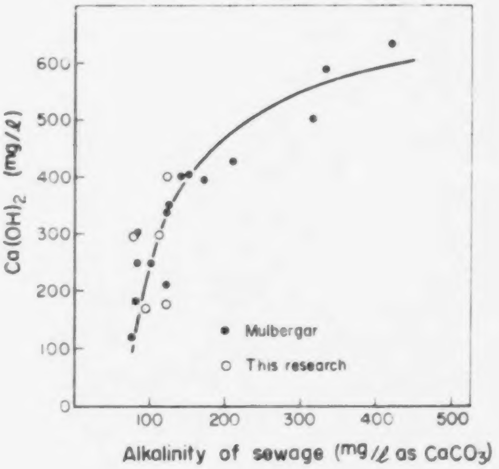

Fig. 5-6 Lime Dosage for pH ≥ 11.0

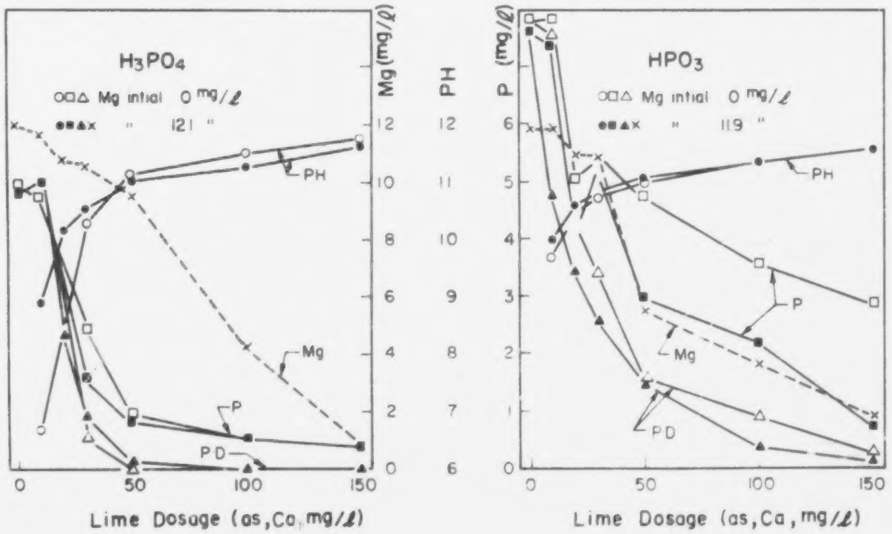

Fig. 5-7 Effect of Magnesium on Lime Precipitation

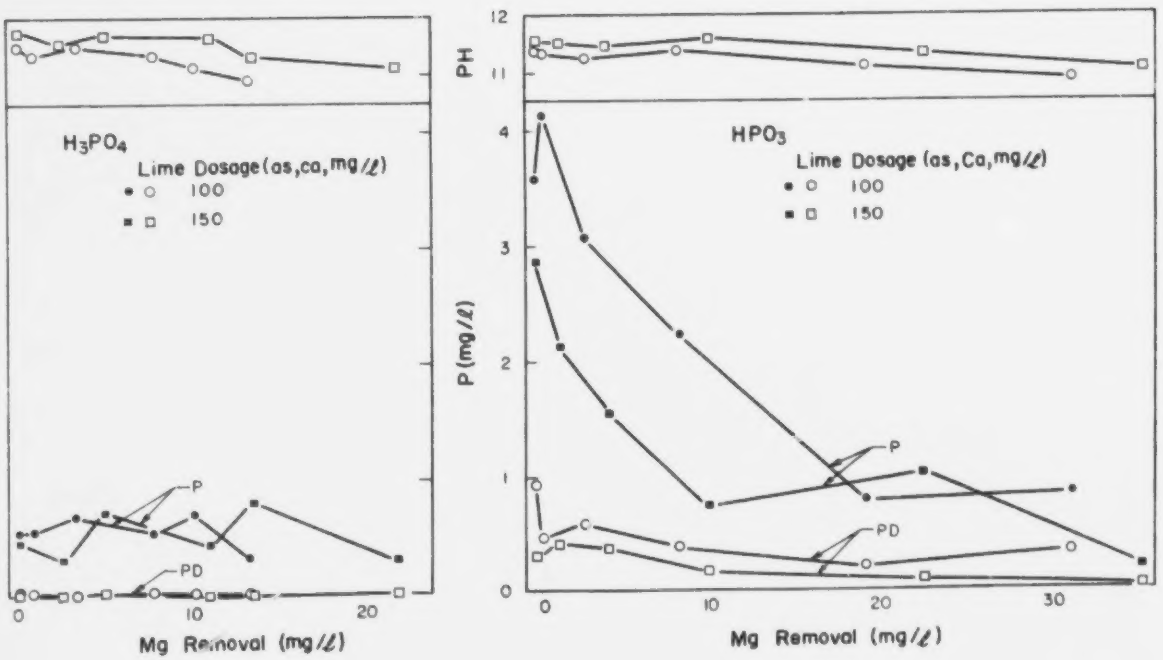

Fig. 5-8 Magnesium Removal vs. Remaining Phosphorus

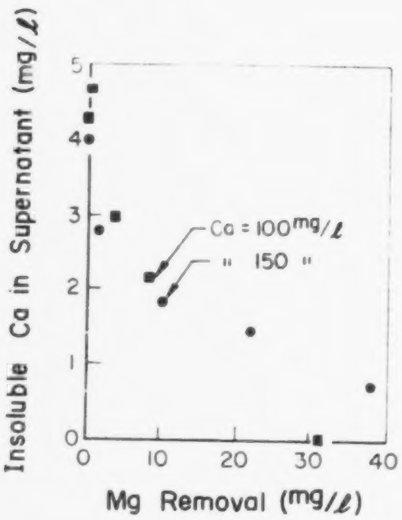

Fig. 5-9 Magnesium Removal vs.
Insoluble Ca in Supernatant

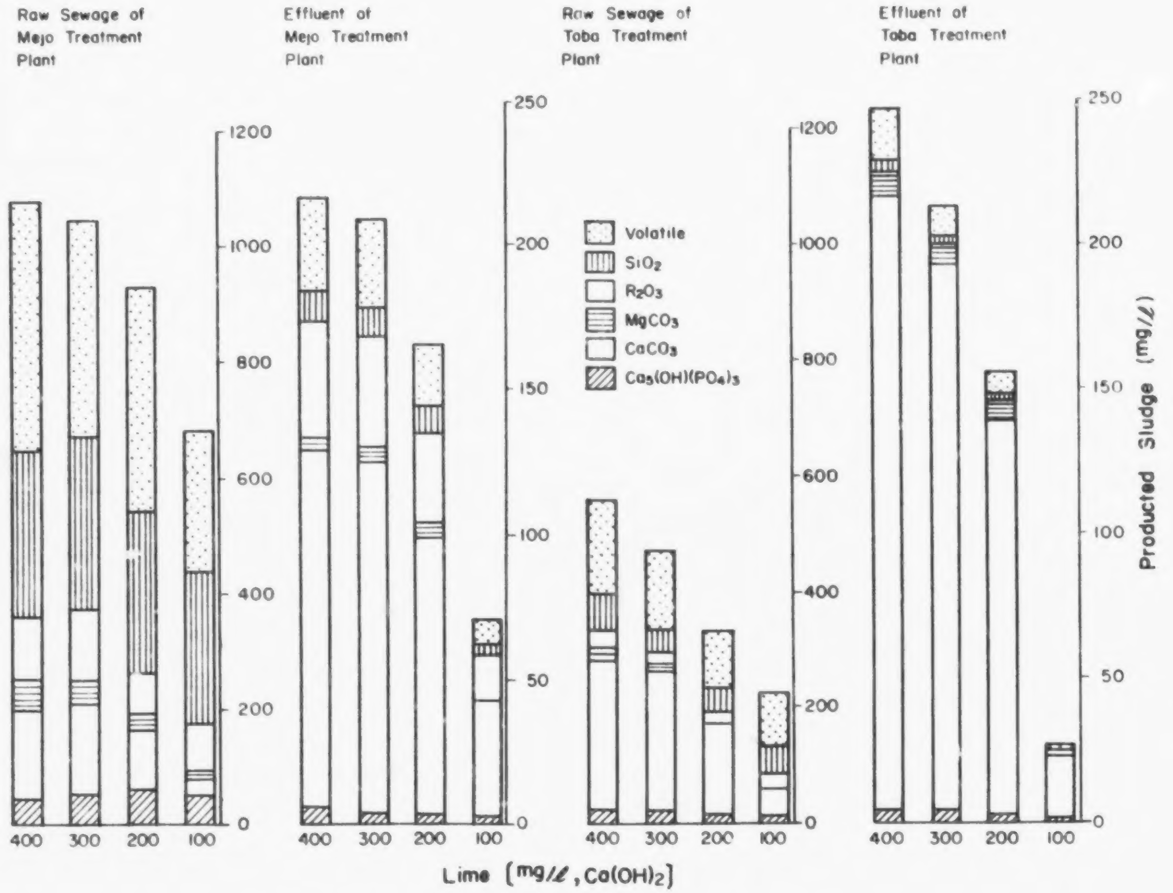

Fig. 5-10 Analytical Results of Lime Sludge

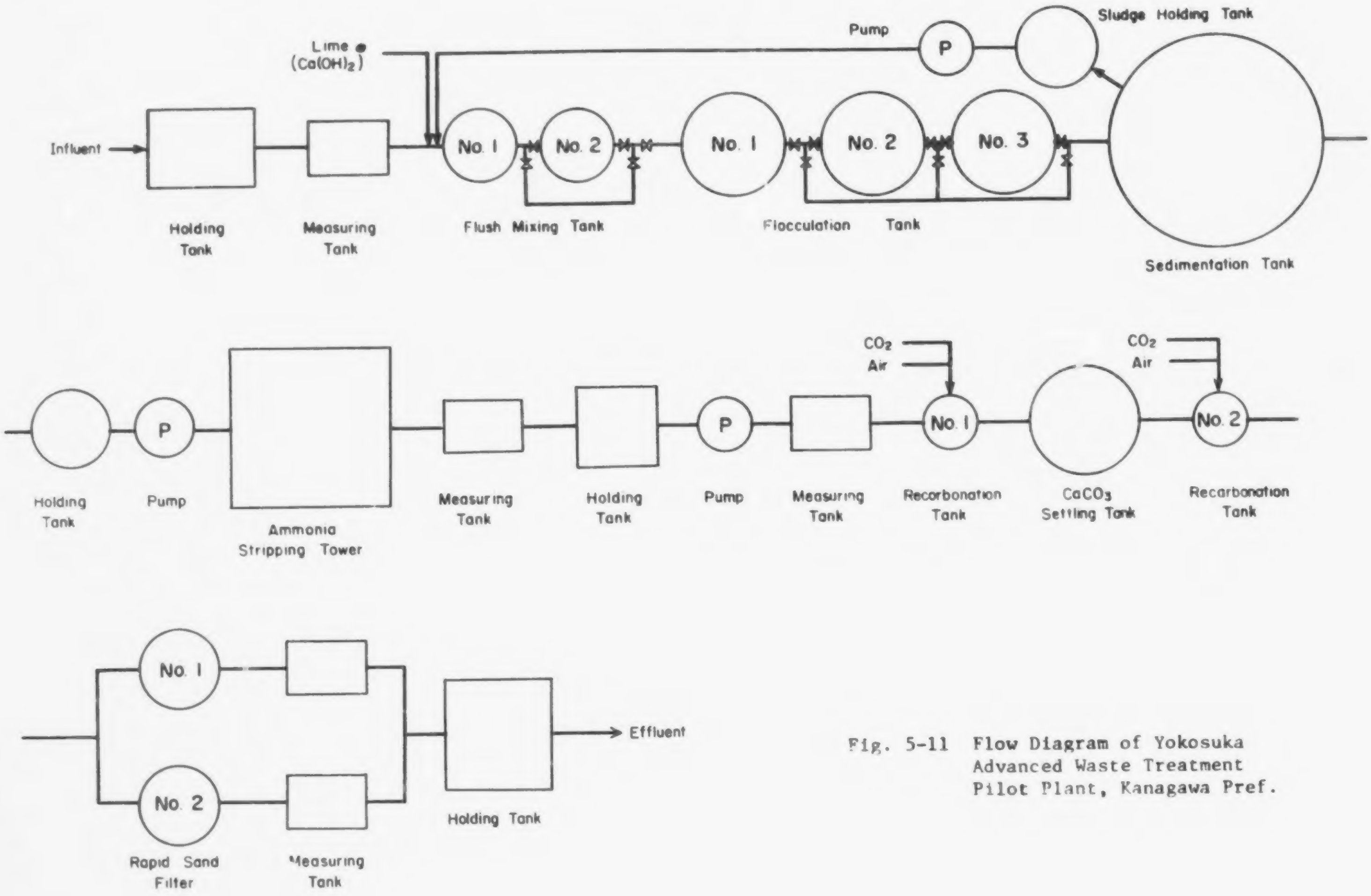

Fig. 5-11 Flow Diagram of Yokosuka Advanced Waste Treatment Pilot Plant, Kanagawa Pref.

US-Japan Conference
on
Sewage Treatment Technology
Paper No. II, III

INDUSTRIAL WASTE TREATMENT TECHNOLOGY IN JAPAN
PROGRESS AND PLANS FOR SEWAGE WORKS IN JAPAN

December 1-6, 1972

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II INDUSTRIAL WASTE TREATMENT TECHNOLOGY IN JAPAN

II. INDUSTRIAL WASTE TREATMENT TECHNOLOGY IN JAPAN

1. DEVELOPMENT OF TREATMENT TECHNIQUE OF INDUSTRIAL WASTE WATER

1-1 Metal Plating Industry

Metal plating industry in Japan, factories are in small scale.

Waste water from metal plating factories, though its amount is rather small, contains toxic substances, such as cyanide compounds, chromium, copper, zinc, and nickel. In addition the water is strongly acidic or alkaline. Since cyanide compounds and heavy metals such as chromium cause health hazard, their run-off is strictly controlled by law. In treatment of metal plating waste chemical methods with oxidation and reduction are applied for the decomposition of cyanide compounds and removal of heavy metals. Thus, oxidation decomposition with an oxidizing agent such as chlorine, and hydroxide settling are respectively applied for the decomposition of cyanide compounds and for the removal of the above heavy metals (Cr, etc.).

For waste water from metal plating factories, the separation of cyanide waste water from chromium waste water is first carried out, and then the former is sent to an oxidation tank and the latter to a reduction tank. In the oxidation tank or reduction tank an oxidizing or reducing agent is added to the waste water after some preliminary treatment such as settling.

Continuous treatment of waste water from metal plating factories has been developed in recent years. ORP meter will be more frequently used for the control of the feed rate of chemicals. Application of ion exchange methods in chromic acid treatment will be made.

Application of ion exchange methods to the waste water treatment makes the recovery and reuse of useful substances possible. Some of the remarkable features of ion exchange methods are that absorbed substances to ion exchange materials could be recovered in condensed state by extraction and the ion exchange materials can be used repeatedly after suitable treatment.

In the treatment of chromic acid waste water the use of a strong alkaline anion exchange resin makes the complete absorption of chromic acid possible. Insufficient treatment rarely occurs because of remarkable absorption of the acid to the resin regardless of large change in chromic acid concentration and water content in the waste water.

As a better utilization of the sludge from the above treatment, the production of artificial light gravel is now considerably extensively investigated. For example, a product of good quality is obtained from the sludge and expansion shale after mixing and burning. Thus, the sludge (water content 70 - 75 %) is mixed with dry expansion shale. Then spherical pellets 3 - 15 mm in diameter are prepared from the mixture, dried in hot air, and finally burned in the temperature range of 400 to 1,200°C. For the mixing ratio of the sludge 10 - 12 % to the shale 88 - 90 %, a good product of density 1.2 - 1.4, water content 2.0 - 2.2 %, and compressive strength (28 days) 497 Kg/cm^2 was obtained.

Joint Treatment of the Metal Plating Waste Water

Because of metal plating factories in small scale the joint treatment of the waste water under collective enterprise rather than individual treatment by each factory is more efficient and already conducted at several places. For instance, Katsushika metal plating co-operative association in Tokyo started a joint treatment under participation of 12 companies in 1968. According to the association good results have been obtained by the joint treatment under the following conditions: the application of alkaline chlorine in separation and of a chromium reduction method. The treatment equipment floor area, the cost of construction, the amount of water treated a day, operation time a day are 170 m^2, 12.55 million yen, 230 - 235 m^3/day, and 8 - 10 hrs/day respectively. The running cost at maximum and average are 370 thousand yen/month and 270 - 300 thousand yen/month respectively.

1-2 Food Industry

(Feature of Food Industry in Japan)

Japan's food industry has many varieties in scale ranging from large enterprise in alcohol fermentation and beer brewing to small household industries of manufacturing starch, fish and meat, and others. The total effluent amount of waste water a day exceeds 1,000 m^3 only in a small number of factories, and is less than 500 m^3 in most of small factories. The effluent amount and quality of the waste water are greatly affected by seasonal operation, location of factories, and others.

(Feature of Waste Water in Food Industry)

Raw materials in food industry being agricultural and marine products, most of pollutants in the waste water are organic compounds, such as carbohydrates, proteins, oils and fats, and organic acids. Some of the pollutants dissolve and others exist in the state of suspension or floatation in the water. Main pollutants have large BOD, caused by a living organic life. High concentration of BOD, and floated and suspended substances are one of the remarkable features of the main pollutants.

(Present Status and Future Trend of Waste Water Treatment)

The removal of floated and suspended substances and of dissolved BOD constituent can be said the main purpose of the treatment of waste water in food industry.

Thus, floatation separation or coagulating sedimentation process is applied to the removal of floated substances and oils and fats. Biological treatment is applied to the removal of dissolved organic matters. Choice of activated sludge process, trickling filter process, or oxidation ditch in the biological treatment depends on the quality and quantity of waste water from factories and their location.

Lagoon pond requires a broad area and has not been made yet in Japan based on the condition of industrial location planning. Oxidation ditch, a modification of the activated sludge process, is sometimes used under the conditions that in a treatment tank 1.0 m in depth of water waste water circulates at flow rate 0.3 m/sec or higher and about 1 - 3 days in residence time. A mechanical surface aeration equipment with 85 - 90 % in treatment efficiency is used for the supply of oxygen. Development of a trickling filter process with plastic filter bed has been given attention in recent years.

In the trickling filter process the waste water fed at the top of a filter flows down through the filter medium. During this process pollutants are subject to absorption destruction by aerobic bacteria adheres as films to the filter surface. For the filter medium of sands or crushed small stones, which have long been used, the filter is heavy and has height limitation, and requires a large floor area. Nevertheless, the treatment efficiency in this traditional filter medium is low. The application of plastics of various kinds to filter medium has been made with the development and wider use of the plastics in recent years. The filter medium of this type (plastics) is light and of high pressure resistance. This makes a high tower type filter 8 - 9 m in height and eventually much less floor area possible. Porosity of the traditional filter medium is about 60 % at maximum, while that of a plastic filter medium is 95 % or higher. In the latter the total surface area per 1 m^3 of filter medium is 130 - 200 m^3, which is considered to be very high, and maximum BOD load a day up to 2.6 kg/m^3 is possible for 90 % or more removal of BOD. It should be emphasized that this treatment efficiency is comparable to that in the activated sludge treatment.

An example of test runs in a frickling plastic filter treatment:

1. Properties of sample waste water (used for washing of rice)

color	white emulsion	BODppm	2,200 - 3,200
transparency (cm)	0.8 - 1.2	CODppm	1,400 - 2,100
pH	3.6 - 5.5	S S ppm	200 - 800

2. Properties of treated waste water

color	light brown	BOD$_{ppm}$	50 - 300
transparency (cm)	2.5 - 4.0	COD$_{ppm}$	150 - 300
pH	7.5 - 8.2	S S ppm	40 - 200

1-3 Dyeing Industry

(Feature of Dyeing Industry in Japan)

Dyeing industry is one of Japan's key industries. Many minor enterprises feature this industry and they produce beautiful dyed goods by traditional or unique technique. Dyeing has the following processes: materials to be dyed ⟶ removal of paste ⟶ refining ⟶ bleaching ⟶ dyeing ⟶ after treatment. Some factories carry out only some of the above processes.

(Properties of waste water in dyeing industry)

Dyeing waste water contains 1, colored matters from dyestuffs 2, SS (suspended solid) 3, foam substances from detergent etc. 4, substances containing COD or BOD. The pH of the waste water is different from that of pure water. The colored matters, worst of the above all and hated by residents near dyeing factories, often cause various pollution problems. The concentration of SS mostly composed of textile chips is about 40 - 120 ppm.

(Ozone treatment of dyeing waste water)

Oxidation treatment of dyeing waste water by ozone has the following features:

1. Because of strong oxidation power of ozone more substances could be treated by ozone than many other chemical agents, and the oxidation rate is also high.
2. pH control is not necessary and the amount of dissolved oxygen in the waste water after ozone treatment could be very large.
3. The amount of ozone generation to be electrically controlled makes automation and higher efficiency possible.

However, the disadvantage should be noticed that the ozone treatment is still more expensive than that of chlorine or some other oxidizing agents. Because of the remarkable decolorization by ozone, study of the application of ozone treatment to dyeing waste water is under way.

Ozone treatment for decolorization is especially effective for hydrophilic dyestuff, but not so for hydrophobic dyestuff. In the latter coagulating sedimentation is also required, for coagulation of hydrophobic dyestuff makes its separation very easy. For the waste water containing both hydrophilic (poor coagulation) and hydrophobic dyestuffs, coagulating sedimentation is necessary in the pretreatment of the waste water.

Introduction of this pretreatment has advantage over individual application of single coagulating sedimentation or ozone treatment, since in this pretreatment decolorization can be made to a great extent and less amount of a coagulant or ozone than that in the above two cases is required. For example, a treatment test on dye ing waste water from a rayon factory showed that for the joint use of coagulation and ozone decolorization efficiency reached 99 % for 12 ppm of a coagulant and 22 ppm of ozone, while for a zinc chloride coagulant in single coagulation treatment decolorization efficiency was only 80 % for 250 ppm of zinc chloride, and for ozone only the efficiency was 85 % for 77 ppm of ozone. In addition to the decolorization effect as mentioned above ozone is also effective for the removal of BOD and COD. About 50 % of COD in most cases and 95 % or higher of BOD depending on test samples can be removed by ozone.

An estimate showed from the above experimental results that the cost required for the treatment amounted to about 30 yen/m^3. It is desired that the cost will be reduced to 20 yen/m^3 or so in future.

Results of Ozone Treatment of Waste Water from a Dyestuff Factory

Processes / Items		Sample (Waste) Water	Coagulating Treatment		Rapid Filtration Treatment		Ozone Treatment		Ozone Single Treatment
			Amount of Fe^{3+} Addition		Filtration Rate 5 m/hr		Amount of Ozone Addition		
			I	II	I	II	I	II	
			25 ppm	12.5 ppm			46 g/m^3	22 g/m^3	73 g/m^3
Decolorizing Efficiency (%)		$T_r = 0.8$ cm	55	70	85	80	100	99	90
COD	ppm	504 437 336	31.2	273	310	27.0	263	205	320
	Removal Efficiency (%)		38.5	25.5	35.5	25.5	48	44	27
BOD	ppm	1,160			89.7		38		205
	Removal Efficiency (%)				0	0	96.7		82.3
Turbidity (ppm)		13.4	20	53.8	4.95	6.5	0	0	12.5
pH		7.6	5.1	6.4			6.3	6.3	6.0
Amount of Ozone Absorption (g/m^3)							38.2	20.2	62
Ozone Absorption Efficiency (%)							82.0	91.8	84.9

Sample (Waste) Water: Rayon Dyeing Factory (Waste) Water

Amount of Waste Water Treatment: 500 *l*/hr

1-4 Petrochemical Industry

(Location of Plants and Properties of Waste Water in Japan's Petrochemical Industry)

Petrochemical industry is defined as the industry for manufacturing many varieties of products from the decomposition products of naphtha. Petrochemical plants complexes in Japan stand along her coastal areas. Plants are large in scale and discharge a large amount of waste water, which often pollutes water for public use in the neibouring area and damages fishes etc. in the nearby marine regions. The waste water has generally the following properties, though they depend on processes:

(1) Most of pollutants are water-soluble organic matters.

(2) The concentration of the pollutants is high and BOD reaches several thousand ppm.

(3) Nourishment content in the waste water is not high enough for the introduction of biological treatment.

(4) The waste water contains oils especially water-soluble oils in rather large quantity.

(Present Waste Water Treatment)

In the treatment of waste from petrochemical plants activated sludge processes have been widely used in Japan for the removal of BOD, COD, and oils.

As an example, the waste water treatment started in 1969 under co-operation of chemical plants in Yokkaichi, Japan is briefly described:

Four companies of Yokkaichi petrochemical complex have been participated in a joint treatment. The waste water from the two companies contains several hundred ppm of BOD and water content is 95 %. BOD concentration in the waste water from the other two companies is about several thousand ppm. The joint treatment has made the dilution of the concentrated waste water, application of activated sludge treatment, and nourishment balance of nitrogen and phosphorous possible. In order to homogenize the quality of the waste water from each chemical plant by open air the water is kept in a residence tank for four hours and then sent to many distribution tanks. This is followed by an activated sludge treatment. The waste water from each distribution tank is fed into a sludge treatment equipment of aeration tanks and settling tanks. Excessive sludge treat to wet oxidation at 250°C and 70 atm by Zimmerman process.

Table shows a result obtained from a test run

Item	Sample Water	Treated Water	Removal Efficiency (%)
pH	11.1	7.6	-
B O D ppm	602	27.3	95.5
C O D (KM_nO_4) ppm	358	84.6	76.5
C O D ($K_2C_{r_2}O_7$) ppm	825	253	69.4
S S ppm	33.8	13.3	

2. PREVENTION OF POLLUTANTS RUN-OFF BY CHANGE IN PRODUCTION PROCESS

For environmental protection measures should be taken for the treatment of pollutants and furthermore for substantial elimination of the generation of pollutants from production processes themselves. At the final stage of environmental protection application of closed processes in technical systems should be made.

In order to reach this goal present production technique should be throughly re-examined from the view point of environmental control and drastic measures should be taken for improvement or change of the run-off processes of pollutants, source of environmental pollution. Technical and economical possibility in the improvement and change of present technique are being studied by an investigation committee under the auspices of the Ministry of International Trade and Industry. Japanese government strongly supports promising projects of epoch-making technique by giving subsidy (subsidiary rate 75 %). In the projects excellent technique for a drastic change in the run-off process of pollutants or for non-production of environmental pollutants in manufacturing systems is included. Patents obtained during the development of the projects are awarded to the enterprise conducting the projects. However, when the patents should be urgently and socially practised law prescribes that their acquisition and practice should be made under the direction of the competent minister.

The projects developed under this system are as follows.

2-1 Closed Technique in the Production Process of Caustic Soda by Electrolysis (Development of a process with no use of mercury)

Caustic soda has been mainly produced by a mercury method, in which mercury is a cathode and the production of caustic soda is carried out by electrolysis. In the mercury method caustic soda of high quality can be obtained, but the complete removal of mercury discharged into the run-off solution is still very difficult.

Efforts have been made for no contamination of mercury in the run-off solution by applying a circulation, absorption, or precipitation method. According to environmental standard in Water Pollution Control Law mercury is "not to be detected" in the run-off. Development of a non-mercury process for the production of high purity caustic soda along this environmental standard is strongly desired.

In this project being developed for no environmental pollution mercury is no longer used, instead the anode and cathode are separated by an ion exchange membrane. High purity caustic soda is obtained by electrolysing sodium chloride aqueous solution and portions of sodium chloride left unreacted are reused after being refined.

2-2 Development of A Closed Process in Pulp and Paper Production

Digestion and bleaching are two main processes in pulp production. Waste water from these processes is discharged out of the production system with insufficient treatment and sometimes causes water pollution in nearby rivers. As one of water pollution prevention measures various methods have so far been tested for removal of pollutants in some kinds of waste water from digestion process. In these methods the waste water is aimed to be treated to meet water quality standard in present Water Pollution Prevention Law. The waste water thus treated is, however, still highly polluted from the view point of non-pollution. The production processes themselves should be subject to substantial change in future.

Under this project being developed digestion and bleaching processes, which were separate ones, are unified into a process and bleached pulp is made. This process is described more in detail in the following:

Bleached pulp is made after the treatment of small wood chips with chlorine dioxide and caustic soda solutions. All of the waste water from this process are collected, concentrated, and then subject to roasting treatment. This is one of completely new processes under development for cleaning of rivers.

Sulfur compounds, a source of offensive odour and have caused many troubles, being unused at all and the waste water being circulated sufficiently, this process is expected to be one of the most promising measures for water pollution prevention in pulp production processes.

2-3 Closed Process in Dyeing Industry

In dyeing industry a large amount of water in the range of 100 to 500 ton per ton of textile is used. Waste water in this industry is, therefore, discharged in large quantity and is colored. For effective use of water and prevention of environmental pollution due to the colored waste water, dyeing processes with non-aqueous solution is strongly expected to be developed.

In a dyeing process with non-aqueous solution under consideration, an organic solvent of hydrocarbons instead of water will be used for special types of dyestuff. Textile is dyed in a dyestuff solution, from which the organic solvent is recovered and reused.

Properties required for the organic solvent are:

(1) inflammability
(2) vaporization at low temperature
(3) being non-toxic
(4) easiness in recovery

Halogeno-hydrocarbons have so far been considered to be promising from the above requirements.

Dyestuff suitable for solvent dyeing is desired to have at least the following properties regardless dyeing methods:

(1) high solubility of dyestuff in a solvent, for the dyestuff is desired to be used in high concentration
(2) high stability of dyestuff to a solvent
(3) high resistibility to light, temperature, and friction

Solubility is extremely important and new dyestuffs different from those used in present aqueous dyeing processes should be developed.

An equipment for solvent dyeing use should be completely airtight to eliminate the loss of a solvent and be efficient enough for solvent recovery. Steam treatment and the application of activated carbon have so far been tested for the recovery of a solvent, but these are at the stages still not suitable enough for practicing. A cost estimate indicates that 97 - 98 % recovery of a solvent is necessary for this new process.

3. REUSE OF INDUSTRIAL WASTE WATER

The amount of use of industrial water (fresh water) in Japan was about 55 million m^3/day in 1967 and increased up to 85 million m^3/day in 1970. With the growth of industrial production at the present rate, especially the enlargement of the scale of industries consuming a large amount of industrial water, industrial water demand will be much stronger in future. The amount of use of industrial water is estimated to amount to 140 million m^3/day in 1980.

To meet the increase of the amount of use of industrial water development of water resources has been made for rivers or underground water. However, in Japan difficulty arises for obtaining of industrial water under her present conditions. The problems are cost increase for development of rivers, land subsidence caused from drawing water from underground, and contamination of industrial water with brine in the coastal areas.

Therefore, industrial waste water and city sewage will have to be recovered as much as possible for reuse. For reuse as industrial water additional and sophicicated treatment is required for waste water treated by ordinary methods. For example, the quality of the run-off waste water treated* at several final stages with coagulating sedimentation, sand filtration, and chlorine sterilization, etc. is not sufficient enough for industrial water use, since corrosion, formation of scale and slime, and foams by ABS take place much more easily for the waste water thus treated. Measures should be soon taken for further improvement of the quality of treated waste water.

For treated waste water to be used as supply water or for products treatment sophicicated treatment lowering the concentration of organic matters and dissolved salts is necessary. Three year project of a highly sophicicated treatment is under way in Japan by a sewage-waste water reuse committee under the auspicies of MITI Activated carbon absorption, and ion exchange membrane treatment, and others have so far been studied since 1970. Five activated carbon absorption towers 1.8 m in diameter installed at an industrial water cleaning plant at Minamisuna-machi is now in operation.

3-1 Reuse of Waste Water in Iron and Steel Industry

In iron and steel industry in Japan 100 - 150 m^3 of water (fresh water 50 - 80 m^3) is used for one ton crude steel production. "Water recycle", in which water once used is recovered, is conducted with 80 - 90 % in recovery efficiency from serious situations in water resources and for environmental pollution prevention. An investigation showed that average recycling rate of water in whole Japan was 44%, while that in iron and steel industry reached 68 %. In the latter major portions of water recycled were for cooling use.

Cooling water in no contact with products is not subject to pollution. Reuse of cooling water could be made simply by lowering the water temperature by a cooling tower. This is now widely conducted, and an example is described below:

In an iron works in scale of 10 million tons in crude steel annual production rate

* This treatment is already under operation

the total daily consumption of industrial water is 5558 ^{4t}/day. Brine consumption is 2620 ^{4t}/day, 46 % of the total daily consumption. The rest of the consumption comes from fresh water. That is, fresh water consumption is 2938 ^{4t}/day (64 % of the total daily consumption). Recycled fresh water forms 91.4 % of the total fresh water and the rest 8.6 %, 255 ^{4t}/day, is newly fed from outside fresh water source. It should be mentioned that the main portions of fresh water are supplied by recycling of water.

Measures to be taken in future for reuse of waste water are:

1. treatment of scales in water used for cooling or washing
2. treatment and utilization of effluent water from a dust collector under air pollution strict control measures
3. treatment of acid waste water used for washing and discharged from a rolling process.

3-2 Reuse of Treated Sewage

A large absorption equipment with large activated carbon pellets at Minamisunamachi cleaning plant began regular operation in April 1971 under the conditions:

Amount of water to be treated:	45 m^3/hr or 1,080 m^3/day
Type of treatment:	absorption by activated carbon pellets followed by filtration
Absorption tower:	1.8 m in diameter, 5.0 m in height, 5 towers steel plate filter press
Filtration:	down-flow filtration and 4 towers in series
Water feed rate:	16.7 m/h or 400 m/day
Activated carbon:	bed height 3 m, weight of packing 3.2 t (for one tower), brand of carbon Pittsburgh 400 (CAL)
Cleaning methods:	surface washing by fixed nozzle intermediate washing by air and water (at a position 50 cm below surface) back flow washing by water (7 - 20 m/h) expansion 20 - 30 % washing time 3 mins for surface washing 3 mins for intermediate washing 30 - 60 mins for back flow washing

Operation:

Regular operation started in April 1971. Daily cleaning was made in April that year. Back flow cleaning began after May 1971 when inlet water pressure in the first tower reached 4 Kg/cm^2. The operation was interrupted on the 20th July and the activated carbon in the first tower was taken out for a recovery test. Water, then, was fed to the second tower instead of the first one. The third, fourth, and fifth tower, which was a spare one, were connected in series and the operation was continued until April 1972.

Quality of a sample water and that of the treated water are shown in **Tables 1 and 2** respectively.

Table–1 Quality of a Sample Water

(April 1971 to December 1971)

Test Items	Range	Average Value
Chromaticity	13 ~ 18	15
A B S	0.3 ~ 1.0	0.5
COD (KM_nO_4)	5 ~ 12	8
COD ($K_2C_{r_2}O_7$)	18 ~ 40	9
B O D	2 ~ 12	5
T O C	7 ~ 16	12
S S	0.8 ~	20.6
Residue on Evaporation	388 ~ 450	406
Dissolved Matter	261 ~ 476	393
NH_4 – N	4 ~ 15	10
NO_3 – N	0.5 ~ 18	10
PO_4^-		2.5
SO_4^-	45 ~ 65	59
Total Fe	0.1 ~ 0.18	0.13
M_n		< 0.01
Hardness	50 ~ 70	60
Alkalinity	30 ~ 70	60
Electric Conductivity ($\mu\nu$/cm)	400 ~ 900	600

Table–2 Quality of the Treated Water

Test Items	Average Value
Chromaticity	0 ~
A B S	0 ~
COD ($KMnO_4$)	2.6
COD ($K_2Cr_2O_7$)	5
B O D	1.5
T O C	4
S S	18.9
Residue on Evaporation	397
Dissolved Matter	388
NH_4 – N	10
NO_3 – N	10
PO_4^{-}	2.5
SO_4^{-}	59
Total Fe	0.13
Mn	0.01
Hardness	60
Alkalinity	60
Electric Conductivity	600

Method of Analysis : JIS K0101

Table–C A Result of the 3rd Treatment of Sewage
by Activated Carbon Colume
(Minamisuna-machi Water Cleaning Plant)

Continuous Filtration Days	Test Items	Sample Water	1st Colume Middle Pt.	1st Colume Exit	2nd Colume Middle Pt.	2nd Colume Exit	3rd Colume Middle Pt.	3rd Colume Exit	4th Colume Middle Pt.	4th Colume Exit	Removal Efficiency (%)
1	pH	7.25	7.25	7.25	7.22	7.22	7.25	7.55	8.60	8.85	
	C O D	8.46	2.13	2.11	2.74	2.74	3.65	1.75	1.93	1.56	81.5
	Chromaticity	15	4	17	5	5	20	4	4	4	
	Turbidity	6.5	2.2	4.5	3.8	3.8	15	2.0	2.2	2.0	
	Total Fe	0.61	0.37	0.36	0.37	0.37	0.33	0.27	0.28	0.23	
	PO_4^{-3}	2.42	1.71	1.56	1.18	1.18	1.36	1.13	1.27	1.62	
	Total N	18	–	–	–	–	–	–	–	16	
2	pH	7.48	–	7.32	–	–	7.35	–	7.32	7.40	
	C O D	8.50	–	2.34	–	–	1.96	–	1.73	1.66	80.5
3	pH	7.48	7.12	7.15	7.15	7.15	7.22	7.18	7.15	7.35	
	C O D	8.60	3.50	2.05	1.68	1.68	1.80	1.66	1.36	1.22	
	Chromaticity	14	–	4	–	–	4	–	3	3	
	Turbidity	5.5	–	3.5	–	–	3.2	–	2.5	2.2	
	Total Fe	0.27	–	0.19	–	–	0.17	–	0.23	0.16	
	PO_4^{-3}	1.64	–	1.74	–	–	1.90	–	2.13	2.13	
	Total N	11	–	–	–	–	–	–		10.4	
4	pH	7.18	–	7.28	–	–	7.20	–	7.20	7.28	
	C O D	6.56	–	2.16	–	–	1.72	–	1.60	1.45	77.9

Fig. 1

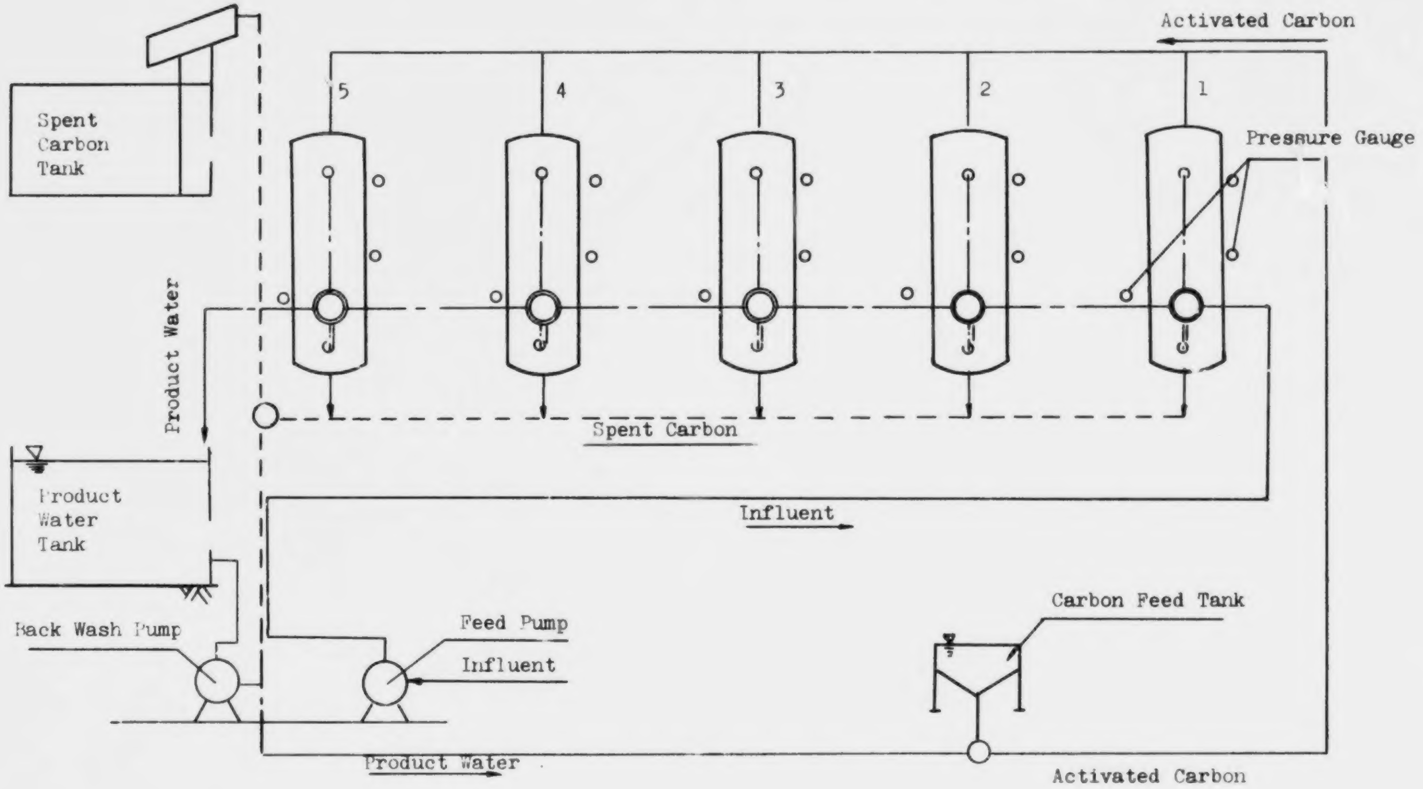
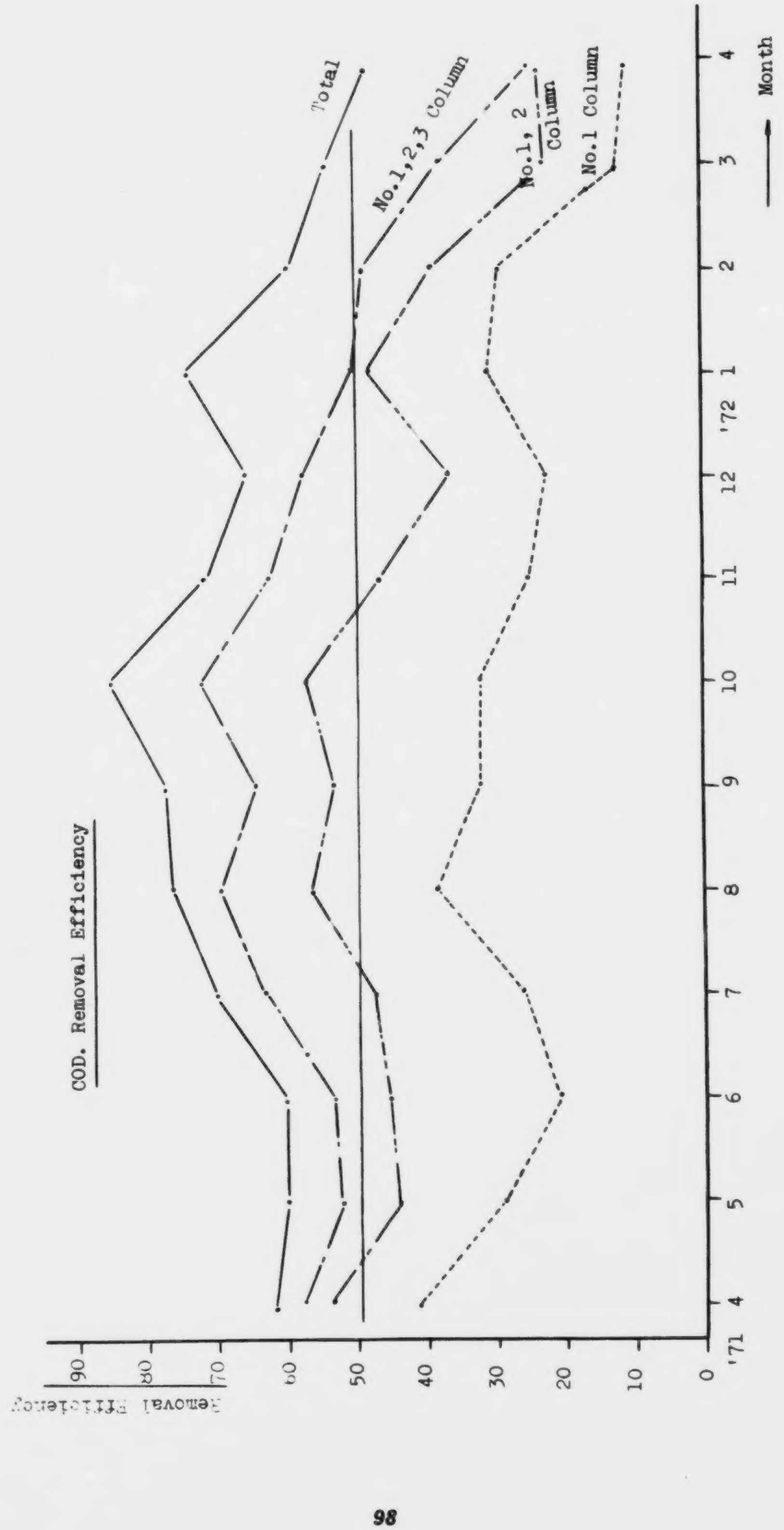

Activated Carbon
5
4
3
2
1
Pressure Gauge
Spent
Carbon
Tank
Product Water
Spent Carbon
Product
Water
Tank
Influent
Carbon Feed Tank
Back Wash Pump
Feed Pump
Influent
Product Water
Activated Carbon

Fig. 2



COD. Removal Efficiency

III DEVELOPMENT OF SEWAGE WORKS IN THE PAST TEN YEARS

III. PROGRESS AND PLANS FOR SEWAGE WORKS IN JAPAN

1. DEVELOPMENT OF SEWAGE WORKS IN THE PAST TEN YEARS

It was in the 1960's when Japan's economy entered the stage of rapid growth that the sewerage improvement began to be accelerated across the country. To be more precise, it can be said that the systematic sewerage improvement was set afoot after the Sewerage Law was enacted in 1958.

Table 1 - 1 shows the trend of GNP and capital investiment in sewage works as well as the proportion of the latter in the former over the past ten years. As will be clear from Table 1-1, investment in sewerage construction pursued a steady upward trend comparable to the growth of GNP up to 1966, but has reamined on the same level thereafter.

Fig. 1 - 1 shows the past record of sewerage system development.

In Japan, the cost of sewerage system construction is financed by the national subsidy, national loan, general municipal revenue prefectural subsidy, and special assessment by landowners in the drainage area.

The rate of the national subsidy was on a very low level unitl 1967 when it was raised substantially by the growing recognition of the need for improving the country's sewerage system. However, considering the fact that sewage works is a public enterprise to be pushed forward from the viewpoint of national interest, the current rate of national subsidy is still very low relative to subsidies granted for implementation of other public works such as road, river and irrigation.

The Five-Year Plan for Sewage Works was initiated in 1963 under the provisions of the Law concerning Urgent Measures for Environmental Sanitation Works (Sewerage, Sewage Treatment, Nightsoil Disposal, Solid Waste), but since 1967 the Five-Year Plan for Sewage Works have been carried out under the provisions of the Law concerning Urgent Measures for Sewage Works and developed to the Second Five-Year (1967 - 1971) and the Third Five-Year (1971 - 1975) shown as Table-1-2.

Table 1-1 GNP and Investment in Sewage Works and Its Ratio in GNP (1963 - 1972)

Year	GNP (B)		Investment in Sewage Works (B)		Ratio (A/B)	
	100 million yen	Index	Million yen	Index	%	Index
1963	255,759	0.783	44,909	0.637	0.1756	0.813
1964	295,305	0.904	55,409	0.786	0.1876	0.869
1965	326,504	1.000	70,500	1.000	0.2159	1.000
1966	381,179	1.167	94,286	1.337	0.2474	1.146
1967	448,015	1.372	108,814	1.543	0.2429	1.125
1968	527,882	1.617	128,042	1.816	0.2426	1.124
1969	624,333	1.912	159,779	2.266	0.2559	1.185
1970	727,181	2.227	189,399	2.687	0.2605	1.207
1971	808,789	2.477	373,802	5.302	0.4622	2.141
1972	930,900	2.851	341,326	4.842	0.3667	1.698

Note: Figures up to 1971 are the values actually recorded for both GNP and capital investment in Sewage Works.

Fig. 1-1 Progress of Public Sewerage System
(Drainage Area/Urban Area)

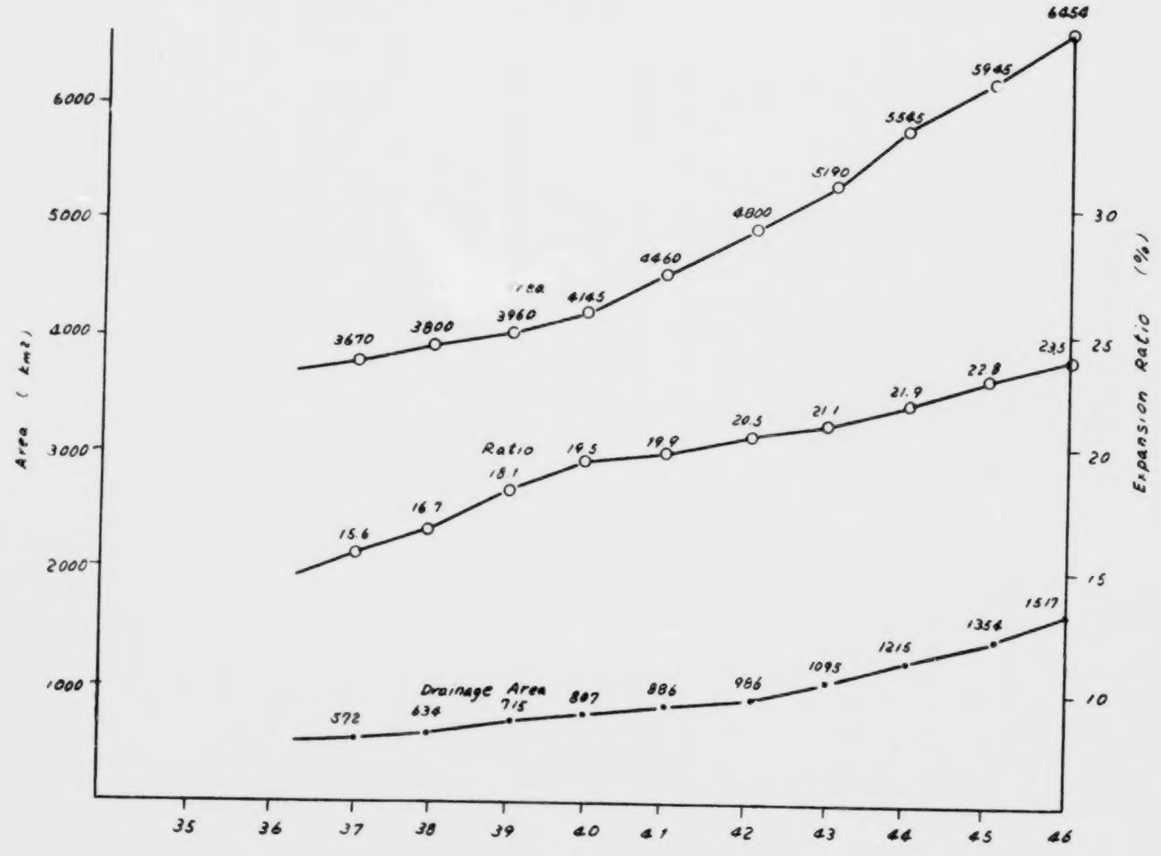


Table 1-2. Investment Third Five Years (1971 - 1976) Construction Plan for Sewage Works

(Unit: Million yen)

Classification	Third Five Year Plan (71 - 75)	Second Five Year Plan (67 - 71)	First Five Year Plan (63 - 67)
Public Sewerage System	2,030,000	780,000	396,000
Subsidized Works	1,157,470	422,000	-
Non-subsidized Works	872,530	358,000	-
Regional Sewerage System	360,000	60,000	-
Subsidized Works	324,000	58,000	
Non-subsidized Works	36,000	2,000	-
Storm Sewer	80,000	50,000	31,000
Subsidized Works	80,000	50,000	-
Specified Public Sewerage	30,00	10,000	13,000
Subsidized Works	25,530	10,000	-
Non-subsidized Works	4,470	-	-
Reserve Fund	100,000	30,000	-
Total	2,600,000	930,000	440,000
Total Cost of Subsidized Works	1,587,000	540,000	-
Total Cost of Non-subsidized Works	913,000	360,000	-

2. ESTABLISHMENT OF ENVIRONMENTAL WATER QUALITY STANDARDS AND COUNTERMEASURES

2-1 Introduction

In accordance with the provision[1] of the Basic Law for Environmental Pollution Control, for establishing environmental quality standards, national water quality standards were decided at the Cabinet Meeting in April 1970. The standards, as shown in Table 2-1 are divided into two categories, that is, quality standards concerning human health and standards concerning the living environment. Water Quality standards concerning the living environment are set separately depending on the use and type of water areas, such as rivers, lakes, reservoirs and coastal waters.

The water quality standards concerning human health are set for eight substances, cyanides, alkyl mercury, organic phosphorus, cadmium, lead, sexivalent chrome, arsenic and total mercury, and are applied to all public water areas. It is expected that the standards will be maintained at all times. Monitoring of water quality with regard to these eight substances is to be carried out to determine whether the standards are maintained regardless of the volume of water in a given public water area. As for the new substances which adversely affect human health such as PCB and other noxious matters, the Environment Agency has been studying the influences of these substances on human health for the purpose of including them in the list of items of the standards.

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[1] Article 9, Chapter 2 of the Basic Law for Environmental Pollution Control

TABLE 2-1(a) WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES

cyanide	*
alkyl mercury	*
organo-phosphorus compounds	*
cadmium	0.01 mg/1
lead	0.1 mg/1
chromium (hexavalent)	0.05 mg/1
arsenic	0.05 mg/1
total mercury	*

* must be undetectable by the prescribed examination method

TABLE 2-1(b) WATER QUALITY STANDARDS FOR ORDINARY POLLUTANTS

(Rivers)

	pH	BOD (mg/l)	SS (mg/l)	DO (mg/l)	MPN (100ml)
Class-AA	6.5 - 8.5	1	25	7.5	50
" A	"	2	"	"	1000
" B	"	3	"	5.0	5000
" C	"	5	50	"	---
" D	6.0 - 8.5	8	100	2.0	---
" E	"	10	---	"	---

(Lakes)

	pH	COD	SS	DO	MPN
Class-AA	6.5 - 8.5	1	1	7.5	50
" A	"	3	5	"	1000
" B	"	5	15	5.0	---
" C	6.0 - 8.5	8	---	2.0	---

(Coastal Waters)

	pH	COD	DO	MPN
Class-A	7.8 - 8.3	2	7.5	1000
" B	"	3	5.0	---
" C	7.0 - 8.3	8	2.0	---

2-2 Types of Environmental Water Quality Standards concerning the Living Environment

The environmental water quality standards concerning the living environment in each water area are as follows:

For rivers six types of standards from AA to E, are set for five items, potential of Hydrogen (pH), biochemical oxygen demand (BOD), suspended solids (SS), dissolved oxygen (DO) and coliform groups. For lakes, reservoirs and marshes, four types of standards, from AA to C, are set for the same five items. For coastal waters three types of standards, A, B and C, are set for pH, COD, DO, coliform groups and normal-hexane extracts. The Environment Agency is planning to include substances which cause eutrophication of lakes such as nitrogen and phosphorous in the list for standards and new indexes concerning the living environment such as total oxygen demand (TOD), total organic carbon (TOC) and others.

On June 1, 1971, the power of applying water quality standards to individual water areas was transferred from the central Government to the prefectural governments, except for 47 water areas which extend over two or more prefectures and which require coordination between the prefectural governments concerned.

Classification of a specific body of water as a particular type, which will then determine the water quality standards to be enforced, is based on the present and future beneficial uses of the water area, its present water quality and the location of polluting sources. While considering these factors the opinions of the prefectural governor concerned and other related persons are heard. The period during which the standards are to be met is classified into one of three categories, a, b or c, meaning "immediately," "within five years," or "more than five years," respectively. The water quality standards applied and the period during which the standards are to be achieved must be publicly announced for each area as soon as determined. Measurements of pollutant related to the enforcement of living environment quality standards are to be carried out in an appropriate manner when the water areas are in normal condition (in the case of rivers, when the flow volume is a level higher than 275-day discharge and in the case of lakes, when the water level is higher than the "low water level").

2-3 Application of Environmental Water Quality Standards and Future Prospects.

By March, 1977, the Environment Agency is planning to designate 600 principal water areas throughout Japan as areas to which environmental water quality standards are applied.

Priority has been given to the application to the following water areas where control measures are urgently needed:

a. Such areas where water has been already polluted,
b. Such areas where large-scale development for housing or new industrial plants are being planned,
c. Closed water bodies such as lakes and bays where eutrophication has already occurred or is very likely to occur.

As mentioned above, then central Government designates inter-prefectural water areas and applies the water quality standards to 47 while prefectural governments take charge of other local water areas. By the end of 1972, the number of water areas designated by the central Government will be 22 and the number of water areas designated by the local governments will be 118. The ratio of designated water areas to the total water areas is approximately 25%. Since these water areas include those in large industrial cities such as Tokyo, Osaka, Nagoya, Kita-kyushu, etc., the aforesaid 25% will cover approximately 65% in terms of the total population and 80% in terms of overall industrial shipment.

2-4 Measures to Maintain Environmental Water Quality Standards

The central Government takes the following measures to maintain the environmental water quality standards:

(1) Stricter restriction on waste water discharge:

The effluents discharged from industrial plants or other places of business which have "specific facilities" for discharging sewage or waste water into public water bodies, as designated by the Cabinet Order, are regulated to conform to the effluent standards (Table 2-2) by the Water Pollution Control Law. The "specific facilities" (Table 2-3) include almost all facilities liable to pollute public waters. The factories or establishments which intend to establish any "specific facilities" shall submit a report to the competent prefectural governor. The prefectural governor examines the report and if he finds that the effluent does not satisfy the effluent standards, he may order the person who submitted the report to modify the reported facility, the method of utilization of the "specified facility" or the process for the treatment of the polluted water, etc.

The effluent standards are divided into two categories, that is, the national uniform standards and the stricter prefectural standards. The national uniform standards shown in Table 2 are applicable to all kinds of effluent throughout Japan. The stricter effluent standards are set by prefectural governments by their ordinances and enforced instead of the uniform standards when it is found that the uniform national effluent standards cannot maintain the environmental water wuality standards.

So far, stricter standards have been established by about two thirds of the prefectures, and it is expected that all the prefectures will establish such standards by the end of the fiscal year 1972. These stricter standards will be revised in accordance with the changes of the conditions of water pollution and scientific or technical developments.

Table 2-2 (a) Effluent Standards for Toxic Substances

cadmium	0.1 mg/l
cyanide	1 mg/l
organic phosphorous compounds	1 mg/l
lead	1 mg/l
sexivalent chrome	0.5 mg/l
arsenic	0.5 mg/l
total mercury	*
alkyl mercury	*

* must be undetectable by the prescribed examination method

Table 2-2 (b) Effluent Standards for ordinary pollutants

pH	5.8 - 8.6 (for effluent discharged into public water bodies other than coastal waters) 5.0 - 9.0 (for effluent discharged into coastal waters)
BOD	160 mg/l (daily average 120 mg/l)
SS	200 mg/l (daily average 150 mg/l)
N-hexane extracts	5 mg/l (mineral oil) 30 mg/l (animal and vegetable fats)
Phenols	5 mg/l
Copper	3 mg/l
Zinc	5 mg/l
Dissolved iron	10 mg/l
Dissolved manganese	10 mg/l
Chrome	2 mg/l
Fluorine	15 mg/l
Number of Coliform groups (per cc)	3,000 (daily average)

TABLE 2-3 (A)

THE SPECIFIED FACILITIES

1. MINING AND COAL WASHING

   (a) ore separation facilities, (b) coal dressing facilities, (c) neutralization and sedimentation facilities of mine water, (d) solids separation facilities from water used for digging.

2. MEAT PACKING AND POULTRY PROCESSING

   (a) initial preparation facilities, (b) washing facilities, (c) cooking facilities.

3. SEA FOODS MANUFACTURING

   (a) initial preparation facilities, (b) washing facilities, (c) dehydration facilities, (d) screening facilities, (e) cooking facilities.

4. CANNED AND FROZEN VEGETABLES AND FRUITS MANUFACTURING

   (a) initial preparation facilities, (b) cleaning facilities, (c) pressing facilities, (d) cooking facilities.

5. MISO, SOY-SOURCE, EDIBLE AMINO ACID, GLUTAMIC ACID, VEGETABLE SOURCES AND VINEGAR MANUFACTURING

   (a) initial preparation facilities, (b) cleaning facilities, (c) boiling facilities, (d) concentration facilities, (e) finishing facilities, (f) straining facilities.

6. WHEAT FLOUR MANUFACTURING

   (a) washing facilities.

7. SUGAR MANUFACTURING

   (a) initial preparation facilities, (b) washing facilities, (c) filtration facilities, (d) separation facilities, (e) refining facilities.

8. BAKERY AND CONFECTIONARY

   (a) bean-jam processing facilities.

9. RICE CAKE AND MALT MANUFACTURING

   (a) washing facilities.

10. SOFT DRINK MANUFACTURING AND BREWERY

(a) initial preparation facilities, (b) cleaning facilities, (c) extraction facilities, (d) straining facilities, (e) boiling facilities, (f) stilling facilities.

11. FEED STAFF AND ORGANIC FERTILIZER MANUFACTURING

(a) initial preparation facilities, (b) washing facilities, (c) pressing facilities, (d) vacuum concentration facilities, (e) water flusing deodorization facilities.

12. OIL AND FAT MANUFACTURING

(a) initial preparation facilities, (b) washing facilities, (c) pressing facilities, (d) separation facilities.

13. YEAST MANUFACTURING

(a) initial preparation facilities, (b) washing facilities, (c) separation facilities.

14. STARCH MANUFACTURING

(a) soaking facilities, (b) washing facilities, (c) separation facilities, (d) waste pits.

15. DEXTROSE MANUFACTURING

(a) initial preparation facilities, (b) filtration facilities, (c) refining facilities.

16. NOODLES MANUFACTURING

(a) boiling facilities.

17. BEAN FOODS MANUFACTURING

(a) boiling facilities.

18. INSTANT COFFEE MANUFACTURING

(a) extraction facilities.

19. TEXTILE INDUSTRY

(a) scouring facilities, (b) by-product processing facilities, (c) soaking facilities, (d) finishing facilities, (e) silket machine, (f) bleaching facilities, (g) dyeing facilities, (h) chemical treatment facilities.

20. WOOL SCOURING AND WASHING

(a) wool scouring and washing facilities, (b) carbonizing facilities.

21. SYNTHETIC TEXTILE MANUFACTURING
(a) spinning facilities, (b) chemical treatment facilities, (c) recovery facilities.

22. CHEMICAL FINISHING OF WOODS
(a) wet barket, (b) chemical soaking facilities.

23. PULP AND PAPER MANUFACTURING
(a) soaking, (b) wet barker, (c) chiper, (d) digester, (e) accumulater for digester wastes, (f) chip refiner and pulp refiner, (g) bleaching facilities, (h) paper mill, (i) collophane paper mill, (j) wet fiber plate facilities, (k) waste gas washing facilities.

24. FERTILIZER MANUFACTURING
(a) filtration facilities, (b) separation facilities, (c) water jet breaking facilities, (d) waste gas washing facilities, (e) wet dust collecter.

25. SODIUM HYDROXIDE AND POTASSIUM HYDROXIDE MANUFACTURING (MERCURY ELECTROLYSIS)
(a) electrolyte refining facilities, (b) electrolyzing facilities.

26. INORGANIC PIGMENTS MANUFACTURING
(a) washing facilities, (b) filtration facilities, (c) centrifuger (cadmium and its compounds), (d) water flushing separater (verdigris), (e) waste gas washing facilities.

27. INORGANIC CHEMICALS MANUFACTURING EXCLUDING ITEMS OF 25 AND 26
(a) filtration facilities, (b) centrifuger, (c) sulfur dioxide gas cooling and washing facilities (sulfuric acid), (d) washing facilities (activated carbon and carbonated disulfur), (e) hydrochloric acid regenerating facilities (silicate anhydrous), (f) reactor (cyanides), (g) absorber and sedimentation facilities (iodines), (h) sedimentation facilities (saline magnesia), (i) water flushing facilities (bariumates), (j) waste gas washing facilities, (k) wet dust collecter.

28. ETHYLENE DERIVATES MANUFACTURING (CARBIDE PROCESS)
(a) wet ethylene generating facilities, (b) washing facilities and still (acetate ester), (c) methyl alcohol still (polyvinyl alchohol), (d) still (acrylic acid ester), (e) vinyl chloric monomer washing facilities, (f) chlorprene monomer washing facilities.

29. COAL TAR PRODUCTS MANUFACTURING

(a) sulfuric acid washing facilities of benzene relates, (b) waste pits, (c) tar sodium fulfonate reactor.

30. FERMENTATION INDUSTRY EXCLUDING ITEMS OF 5, 10 AND 13

(a) initial preparation facilities, (b) still, (c) centrifugal decanter, (d) filtration facilities.

31. METHANE DERIVATES MANUFACTURING

(a) still (methyl alcohol and 4-chloromethane), (b) refining facilities (folmaldehyde), (c) washing and filtration facilities (flone gas).

32. SYNTHETIC PLASTIC MANUFACTURING

(a) filtration facilities, (b) water washing facilities (pigments or dye lake) (c) centrifugal decanter, (d) waste gas washing facilities.

33. SYNTHETIC PLASTIC MANUFACTURING

(a) condensation reactor, (b) water washing facilities, (c) centrifugal decanter, (d) settling facilities, (e) cooling gas washer and still (florides plastics), (f) diluent still (polypropylene), (g) diluent still (polyetylene), (h) acid and alkali treatment facilities (polybutane), (i) waste gas washing facilities, (k) wet dust collecter.

34. SYNTHETIC RUBBER MANUFACTURING

(a) filtration facilities, (b) dehydration facilities, (c) washing facilities, (d) latex concentration facilities, (e) sedimentation facilities (styrenebutadiene, nitrile-butadiene and polybutadiene-gum).

35. ORGANIC GUM CHEMICALS MANUFACTURING

(a) destillation facilities, (b) waste gas washing facilities, (c) wet dust collecter.

36. SYNTHETIC DETERGENT MANUFACTURING

(a) acid washing and separating facilities, (b) waste gas washing facilities, (c) wet dust collecter.

37. PETROCHEMICAL INDUSTRIES (CARBOHYDRATE AND ITS DERIVATES) EXCLUDING ITEMS FROM 31 TO 36 AND 51

(a) washing facilities, (b) separation facilities, (c) filtration facilities,

(d) distillation and rapid cooling facilities (acrylonitril), (e) distillation facilities (acetoaldehyde, eterphatalic acid, ethylene diamine), (f) acid and alkali treatment facilities (alkyl benzene), (g) distillation facilities and sulphuric acid concentration facilities (iso-propyl alcohol), (h) distillation and condensation reactor (alcohol), (c) gas cooling and washing facilities (phtalic acid anhydride), (j) acid and alkali treatment facilities (cyclohexane), (k) methylalcohol distillation facilities and acid, alkali treatment facilities, (l) steam condensor (ethyl ketone), (m) methylalcohol recovery facilities and reactor (methy-m-acrytate monomer), (n) waste gas washing facilities.

38. SOAP MANUFACTURING

(a) initial preparation facilities, (b) salting out facilities.

39. HYDROGENATED OIL MANUFACTURING

(a) alkali conditioning facilities, (b) deodorization facilities.

40. FATTY ACIDS MANUFACTURING

(a) distillation facilities.

41. PERFUMERY MANUFACTURING

(a) washing facilities, (b) extraction facilities.

42. GELATINE AND GLUE MANUFACTUIRNG

(a) initial preparation facilities, (b) lime soaking facilities, (c) washing facilities.

43. PHOTO SENSITIVE GOODS MANUFACTURING

(a) washing facilities.

44. NATURAL RESIN MANUFACTURING

(a) initial preparation facilities, (b) dehydration facilities.

45. WOODS CHEMICAL MANUFACTURING

(a) furfural distillation facilities.

46. ORGANIC CHEMICALS MANUFACTURING EXCLUDING ITEMS FROM 28 TO 45

(a) water washing facilities, (b) filtration facilities, (c) concentrator (hyrazide), (d) waste gas washing facilities.

47. PHARMACEUTICAL MANUFACTURING

(a) initial preparation facilities, (b) filtration facilities, (c) separation facilities, (d) mixing facilities, (e) gas washing facilities.

48. GUNPOWDER MANUFACTURING

(a) washing facilities.

49. PESTICIDES MANUFACTURING

(a) mixing facilities.

50. REAGENT MANUFACTURING

(a) processing facilities.

51. OIL REFINING INDUSTRY

(a) desalting facilities, (b) crude petroleum distillation facilities, (c) desulfurization facilities, (d) washing facilities (volatile oil, kerosene, or gasoline), (e) lubricant washing facilities.

52. LEATHER MANUFACTURING

(a) washing facilities, (b) lime soaking facilities, (c) tannin soaking facilities, (d) chrome bathing facilities, (e) dyeing facilities.

53. GLASS MANUFACTURING

(a) grinding and washing facilities, (b) gas washing facilities.

54. CEMENT MANUFACTURING

(a) centrifuger, (b) shaper, (c) wet conditioning facilities.

55. READY MIXED CONRETE MANUFACTURING

(a) batcher plant.

56. ORGANIC SAND BOARD MANUFACTURING

(a) mixing facilities.

57. SYNTHETIC BLACK LEAD ELECTRODE MANUFACTURING

(a) shaping facilities.

58. RAW POTTERY MATERIALS MANUFACTURING

(a) water jet crusher, (b) separation facilities, (c) acid treatment facilities,

(d) dehydration facilities.

59. MACADAM QUARRING
(a) water jet crusher, (b) separation facilities.

60. GRAVEL QUARRING
(a) separation facilities.

61. IRON INDUSTRY
(a) tar and gas separation facilities, (b) gas cooling and washing facilities, (c) rolling facilities, (d) hardening facilities, (e) wet dust collecter.

62. NONFERREOUS METALS MANUFACTURING
(a) reduction basins, (b) electrolysis facilities, (c) hardening facilities, (d) mercury refinery facilities, (e) waste gas washing facilities, (f) wet dust collecter.

63. METARIC GOODS MANUFACTURING AND MACHINERY INDUSTRY
(a) hardening facilities, (b) surface treatment facilities (electrolysis), (c) cadmium electrode and lead electrode processing facilities, (d) mercury refining facilities, (e) waste gas washing facilities.

64. TOWN GAS AND COKE MANUFACTURING
(a) cool-tar and gas-liquid separation facilities, (b) cooling and washing facilities including desulfurization facilities.

65. (a) acid and alkali treatment facilities of metal surface.

66. (a) electro-plating facilities.

67. LAUNDRY
(a) washing facilities.

68. PHOTO DEVELOPING
(a) automatically washing facilities of film.

69. (a) slaughter house.

70. (a) waste oil treatment facilities.

71. (a) automatically washing facilities of car.

72. (a) night soil treatment plant (more than 501 polulation served.)

73. (a) sewage treatment plant.

74. (a) waste water treatment plant.

TABLE 2-3 (B)

THE SPECIFIED FACILITIES DISCHARGING TOXIC SUBSTANCES

TOXIC SUBSTANCES	SPECIFIED FACILITIES *
MERCURY AND ITS COMPOUNDS	25(a), (b), 26(a), (b), (c), 27(a), (b), (j), (k), 28(e), 46(a), (b), (d), 47(b), (c), (d), (e), 62(d), (e), (f), 63(d), (e).
CADMIUM AND ITS COMPOUNDS	26(a), (b), (c), (e), 27(a), (b), (j), (k), 37(a) .... (p), 43(a), 46(a), (b), (d), 53(a), (b), 62(e), (f), 66(a).
LEAD AND ITS COMPOUNDS	23(a), (b), (e), 27(a), (b), (j), (k), 46(a), (b), (d), 47(b), (c), (d), (e), 53(a), (b), 72(e), (f), 63(c), (e).
ORGANO PHOSPHOROUS COMPOUNDS	46(a), (b), (d), 49(a).
CHROMIUM AND ITS COMPOUNDS	22(b), 26(a), (b), (e), 27(a), (b), (j), (k), 32(a), (b), (c), (d), 46(a), (b), (d), 47(b), (c), (d), (e), 63(b), (e), 65(a), 66(a).
ARSENIC AND ITS COMPOUNDS	22(b), 24(a), (b), (c), (d), (e), 27(a), (b), (j), (k), 47(b), (c), (d), (e), 62(a), (b), (e), (f), 65(a).

* Numbers which appear under Specific Facilities correspond to the numbers which appear in Table 2-3(A).

(2) Improvements and provision of pollution control facilities:

For the effective implementation of water pollution control measures for the public waters, various measures should be taken to improve and provide pollution prevention facilities in parallel with the enforcement of the regulatory measures of waste water discharge, in view of the important role played by the pollution prevention facilities, such as public sewage disposal facilities, waste oil disposal facilities, etc. Above all, improvement of sewage system is to be urgently carried out in such areas which are or are likely to be densely populated.

(3) Land utilization and appropriate location of facilities:

For the purpose of water pollution control in public waters, effective application of the regulatory measures for land utilization shall be taken to coordinate and rationalize the present disorderly utilization of land so that housing and factories may be properly located.

In such waters where pollution is or is likely to become serious, some effective measures are to be taken to restrict establishment of such facilities which will deteriorate water pollution. Also a sufficient consideration should be given through preliminary surveys to prevent water pollution in planning and implementing programs for development and improvement of city areas or in inviting industries.

(4) Improvement of water flow of rivers:

In order to maintain water quality of rivers, necessary cares should be taken to improve water flow and to maintain flow rate of rivers.

(5) Monitoring and surveillance:

The system of monitoring and surveillance is being established for the purpose of learning the actual condition of water pollution in public waters, and enforcing regulatory measures for the effective prevention of water pollution.

(6) Development of waste treatment technology:

Development of technologies for waste treatment and measuring water quality is being encouraged.

(7) Assistance to local governments:

For the smooth and satisfactory acheivement of all the objectives in improving water quality, the central Government renders assistance including financial aids to the local governments.

Furthermore, the environmental water quality standards, though already established, may be subject to amendment or changes from time to time when necessary due to the change of the water pollution or in the sources or causes of such pollution.

2-5 How Environmental Water Quality Standards Are Maintained in Japan

During the fiscal year 1971 the Environment Agency granted the subsidy of 179 million yen to 46 prefectures and 14 authorized cities which have been monitoring the water quality of their waters. Following are the results:

(Other administrative authorities such as the branches of the Ministry of Construction and the Fishery Agency have been investigating the water quality from their own standpoints. These data are not included in the following.)

1. Monitoring Stations and Standard Methods for Analysis

Toxic substances were measured at 1,966 monitoring stations and substances concerning the living environment were measured at 1,253 monitoring stations (825 in rivers, 45 in lakes and 383 in coastal waters).

Standard methods for analysis authorized by the Cabinet Council were used in the above measurement.

2. Outline of the Result

(1) Toxic substances:

A total of 89,074 samples were taken for the analysis of toxic substances. The number of samples which did not satisfy the environmental water quality standards was 564 (0.6% of the total), which is less than that of 1970. The ratio of individual substances is shown in Table 2-4. The concentration of cyanide, cadmium and lead is as high as that of 1970 as shown in the table.

(2) Substances concerning living environment:

As for substances concerning the living environment, a total of 76,757 samples (58,185 from rivers, 2,612 from lakes, and 15,960 from coastal waters) were analyzed and it was found that 17,235 samples (22.6% of the total -- 13,352 from rivers, 1,147 from lakes, and 2,836 from coastal waters) did not satisfy the environmental water quality standards.

As for rivers, 23% of the samples did not satisfy the standards, the details of which is as follows: AA ..... 21.4%, B ..... 22.0%, C..... 16.9%, D..... 18.0%, E...... 35.3%.

Such items like BOD_5 and coliform group did not satisfy the standards, the percentage of which is 30% as shown in Table 2-5.

As for lakes, 43.9% of the samples did not satisfy the standards and the percentage of Type A and Type B was very small. The percentage of COD and suspended solids which did not satisfy the standards was high.

As for coastal waters, 17.8% of the samples did not satisfy the standards and Type A showed the worst condition.

3. Advices to Prefectures

In view of the above results, the Environment Agency has advised prefectural governors concerned to take the following measures:

a. To make more detailed investigations on the causes, especially on the sources of water pollution;

b. To enforce the monitoring of waste discharge;

c. To enforce stricter effluent standards if necessary; and

d. To take other effective measures.

Table 2-4 Ratio of Toxic Substances Which Did Not Satisfy the Environmental Water Quality Standards

Substances	No. of samples (A)	No. of samples which did not satisfy the standards (B)	Ratio % (B/A)
cyanide	12,453	142	1.2
alkyl mercury	6,624	0	0
organic phosphus	5,116	11	0.2
cadmium	15,944	114	0.7
lead	14,515	202	1.4
chromium	11,532	15	0.1
arsenic	11,530	48	0.4
total mercury	12,360	32	0.3
Total:	89,074	564	0.6

Note: According to the investigations conducted in 1970, the number of samples which did not satisfy the standards was 222 (1.4%) out of 16,164 samples.

Table 2-5 Unsatisfied ratio of item relating to the living environment

(Rivers)

Type	Item	E Number of sampled	F Sample unsatisfied	F/E Ratio (%)
AA	PH	352	1	0.3
	DO	347	2	0.6
	BOD	338	124	36.7
	SS	316	32	10.1
	Coliform group	261	187	71.6
Total		1,614	346	21.4
A	PH	4,038	109	2.7
	DO	4,124	224	5.4
	BOD	4,068	1,257	30.9
	SS	3,961	781	19.7
	Coliform group	2,634	1,806	68.6
Total		18,825	4,177	22.2
B	PH	3,877	218	5.6
	DO	3,742	135	3.6
	BOD	3,805	1,354	35.6
	SS	3,450	904	26.2
	Coliform group	2,230	1,146	51.4
Total		17,104	3,757	22.0
C	PH	1,902	23	1.2
	DO	1,931	173	9.0
	BOD	1,919	766	39.9
	SS	1,948	336	17.2
Total		7,700	1,298	16.9
D	PH	1,148	27	2.3
	DO	1,113	93	8.4
	BOD	1,162	614	52.8
	SS	1,234	113	9.2
Total		4,717	847	18.0

E	PH	2,812	71	2.5
	DO	2,712	917	33.8
	BOD	2,761	1,939	70.2
Total		8,285	2,927	35.3
Total		58,185	13,352	23.0

(Lakes)

Type	Item	E Number sampled	F Unsatis-fied sample	F/E Ratio (%)
AA	PH	36	0	0.0
	DO	36	0	0.0
	COD	36	5	13.9
	SS	36	21	58.3
	Coliform group	36	4	11.1
Total		180	30	16.7
A	PH	437	68	6.4
	DO	427	43	10.1
	COD	433	344	79.4
	SS	424	255	60.1
	Coliform group	331	218	65.9
Total		2,052	928	45.2
B	PH	97	32	33.0
	DO	97	9	9.3
	COD	97	89	91.8
	SS	89	59	66.3
Total		380	189	49.7
Total		2,612	1,147	43.9

(Coastal waters)

Type	Item	E Number sampled	F Unsatis-fied sample	F/E Ratio (%)
A	PH	1,096	142	13.0
	DO	1,090	334	30.6
	COD	1,071	412	38.5
	Oil	234	19	8.1
	Coliform group	530	50	9.4
Total		4,021	957	23.8
B	PH	2,098	351	16.7
	DO	2,089	262	12.5
	COD	2,056	628	30.5
	Oil	528	88	16.7
Total		6,771	1,429	19.6
C	PH	1,757	186	10.6
	DO	1,743	111	6.4
	COD	1,668	253	15.2
Total		5,168	550	10.6
Total		15,960	2,836	17.8

2-6 Water Areas Where Advanced Waste Water Treatment Is Required

When basin sewerage study program and plans for the municipal sewerage system of individual cities are studied, it is found that there are many water areas where advanced waste water treatment is required in order to satisfy the environmental water quality standards.

Unfortunately, water flow of most of the rivers in our country fluctuates and water flow is very especially small in dry seasons. Above all, water flow of rivers in metropolitan areas is relatively small when compared with the discharge of waste water. In some cases, the quantity of effluent from a sewage treatment plant exceeds the amount of the water flow of the river. Therefore, it is absolutely necessary to purity the effluent to some extent before it is discharged into reivers.

Furthermore, eutrophication has become conspicuous in some lakes such as Lake Biwa and Kasumigaura and in some closed coastal waters such as the Seto Inland Sea, the Tokyo Bay and the Osaka Bay. In these areas, advanced treatment is required to remove nitrogen and phosphorus which are considered to be the dominant factors for entrophication. Table 2-6 is the list of water areas where advanced treatment will be required in the future.

Table 2-6 Water Areas Where Advanced Treatment is Required

Name of Waters		Regional and Municipal Sewerage Works
(Rivers)		
Tone	R.	Teganuma R.S. (Chiba Pref.), Maebashi City, Takasaki City, Utsunomiya City, Kenkyugakuen New Town
Ara	R.	Arakawa Right Reaches R.S. (Saitama Pref.), Arakawa Left Reaches R.S. (Saitama Pref., Tokyo Metro.)
Naka	R.	Nakagawa R.S. (Saitama Pref.), Tokyo Metro.
Tama	R.	Tamagawa R.S. (Tokyo Metro.), Kawasaki City
Sakai	R.	Yokohama City, Hiratsuka City
Sagami	R.	Sagamigawa R.S. (Kanagawa Pref.)
Sakawa	R.	Sakawagawa R.S. (Kanagawa Pref.), Odawara City
Sinano	R.	Niigata City, Nagaoka City, Nagano City, Matsumoto City etc.
Oyabe	R.	Oyabegawa R.S. (Toyama Pref.)
Tenryu	R.	Suwako R.S. (Nagano Pref.), Iida City
Shyonai	R.	Shyouaigawa R.S. (Aichi Pref.), Ichinomiya City, Seto City, Tajima City
Kiso	R.	Kisogawa Right Reaches R.S. (Aichi Pref.), Kisogawa Left Reaches R.S. (Aichi Pref.), Gifu City
Yodo	R.	Yodogawa Right Reaches R.S. (Osaka Pref.), Yodogawa Left Reaches R.S. (Osaka Pref.), Katsuragawa R.S. (Kyoto Pref.), Kyoto City, Osaka City
Neya	R.	Neyagawa R.S. (Osaka Pref.)
Ina	R.	Inagawa R.S. (Osaka and Hyogo Pref.), Aigawa R.S. (Osaka Pref.), Toyonaka City
Muko	R.	Mukogawa R.S. (Hyogo Pref.)
Yamato	R.	Yamatogawa Upper Reaches R.S. (Nara Pref.), Yamato Lower Reaches R.S. (Osaka Pref.)
Kako	R.	Kakogawa R.S. (Hyogo Pref.)
(Lakes)		
Kasumigaura	L.	Kasumigaura R.S. (Ibaragi Pref.), Tsuchiura City
Biwa	L.	Biwako R.S. (Shiga Pref.), Otsu City
Shinji	L.	Shinjiko R.S. (Shimane Pref.), Yonago City
(Coastal Waters)		
Matsushima	Bay	Senen R.S. (Miyagi Pref.), Sendai City
Tokyo	Bay	Inbanuma R.S. (Chiba Pref.), Tokyo Metro., Kawasaki City, Yokohama City, Yokosuka City, Chiba City etc.
Hamanako	L.	Seien R.S. (Shizuoka Pref.), Hamamatsu City
Mikawa	Bay	Toyokawa R.S. (Aichi Pref.), Toyohashi City, Gamagori City
Ise	Bay	Nagoya City, Yokkaichi City etc.
Osaka	Bay	Minami Osaka Coast R.S. (Osaka Pref.), Osaka City, Sakai City, Kobe City, Amagasaki City, Nishinomiya City etc.
Seto Inland	Sea	Kojimako R.S. (Okayama Pref.), Otagawa R.S. (Hiroshima Pref.), Okayama City, Hiroshima City, Takamatsu City, Kitakyushu City etc
Hakata	Bay	Mikasagawa R.S. (Fukuoka Pref.), Fukuoka City

Appendix 1

Restriction on Ocean Dumping

- Outline of the Marine Pollution Prevention Law -

Dumping of oily mixture and various kinds of wastes is restricted by the Marine Pollution Prevention Law. Ocean dumping is prohibited as a rule except for the following cases when dumping is permitted by the standards for discharge prescribed by the same Law.

1. Standards for Discharging Oily Mixture:

Ocean dumping of oily mixture shall be permitted in the following cases:

(1) Discharge in case of emergency for crew, cargo and ship

(2) Discharge during navigation under the following conditions:

(i) The rate of discharge should be less than 60 liters per 1 mile sailing distance.

(ii) Oil concentration of bilge should not exceed 100 ppm.

(3) Discharge from ships smaller than 300 tons except for tanker is not restricted.

(4) Discharge of ballast water from tankers and washings from cargo ships which are below certain standards is permitted in areas 50 miles off sea coast under the following conditions:

(i) The rate of discharge should be less than 60 liters per 1 mile sailing distance.

(ii) The amount of oil to be discharged should be less than 1/15000 of the capacity of the tanker.

2. Standards for Discharging Other Wastes

Dumping of domestic and industrial wastes shall be permitted in the following cases:

(1) Discharge in case of emergency for crew, cargo and ship

(2) Discharge of ship wastes such as garbage, excreta, waste water, etc. under the following conditions:

(i) When the number of crew is less than 100

(ii) When the number of crew is more than 100 but the point of dumping is more than 10 kilometers away from harbors or seashores.

(iii) When the number of crew is more than 100 but the point of dumping is less than 10 kilometers away from harbours or seashores under the following conditions:

	Kind of Waste		Standards for Discharge
1.	Combustible wastes such as paper, wood, fiber, plastic (excluding garbage)	a.	Ignition loss should be less than 15%.
		b.	Specific gravity should be more than 1. 2.
		c.	Wastes should not be in the form of powder.
		d.	Wastes should be dumped while proceeding (at the speed faster than 3 knots).
2.	Incombustible wastes such as glass, metal, china, etc.	a.	Wastes should not stay on the surface.
		b.	Wastes should be dumped shile the ship is proceeding (at the speed faster than 3 knots).
3.	Garbage	a.	Wastes should be crushed.
		b.	Wastes should be dumped while the ship is proceeding (at the speed faster than 3 knots).
4.	Untreated excreta	a.	Wastes should be crushed.
		b.	Wastes should be discharged under sea-level.
		c.	Wastes should be discharged while the ship is proceeding (at the speed faster than 3 knots).

(3) Discharge to the reclamation sites approved by the Public Waters Reclamation Law and other dumping spots:

(i) Normal wastes which containing no toxic substance shall be pre-treated to meet the following conditions:

a. No waste, the ignition loss of which is more than 15% shall flow out of these areas.

b. The pH of liquid waste shall be adjusted to 5. 0 - 9. 0.

c. Oily waste shall be incinerated.

(ii) Special wastes containing toxic substances shall be treated to meet the following conditions shown in the table below. In this case the dumping spots shall be enclosed with concrete walls or by any other means in order to prevent wastes from flowing out or oozing out of the enclosure and polluting the surrounding waters. The waste flowing out the dumping spots shall meet the effluent standards concerning human health prescribed in the Water Pollution Control Law.

	Kind of Waste	Pre-treatment, etc.
1.	Sludge or mining slime containing mercury and its compounds	Wastes should be concreted or enclosed within durable vessels or should be sulfurated by burning.
2.	Acid and alkali waste containing mercury and its compounds	Wastes should be enclosed within durable vessels.
3.	Organic sludge containing toxic substances other than mercury	Wastes should be burnt. Wastes should not stay on the surface.
4.	Acid and alkali waste containing toxic substances other than mercury	The pH of wastes should be adjusted to 5.0 - 9.0.
5.	Sludge and mining slime containing toxic substances other than mercury	Layer reclamation with normal soil is required except for the case of water reclamation.

Note: Basic direction of tentative standards of judgement on the content of noxious substances is shown in the Appendix.

(4) Ocean dumping:
The following standards are applicable to the kind of wastes, dumping spots and methods for disposal:

	Kind of Waste	Dumping Spot	Methods of Discharge
1.	Noxious sludge concreted	A-area	Concreted, enclosed with in vessels, or discharged under the conditions in the notes below.
2.	Combustible wastes after incineration, incombustible wastes, incoluble sludge and other settling wastes	B-area	ditto

	Kind of Waste	Dumping Spot	Methods of Discharge
3.	Excreta, organic sludge, acid and alkali waste, pH of which being adjusted	C-area	Dispersive discharge under the condition in the notes below
4.	Combustible wastes after incineration and inorganic ship wastes	C-area	Specific gravity of waste should be more than 1. 2. Wastes should not be in the form of powder.
5.	Vegetable wastes from ship	C-area	Wastes should be dumped while the ship is proceeding.
6.	Animal wastes from ship and contaminated washings from ship holds	D-area	Methods arenot specified.
7.	Innoxious sludge and waste water from ship excluding washings of 6.	E-area	Discharge is not permitted while the ship is proceeding.

Note: (1) Requirements for concentrated discharge
- (i) Specific gravity should be more than 1. 2.
- (ii) Wastes should not be in the form of powder.
- (iii) Wastes should not be dumped while the ship is proceeding.

(2) Requirements for dispersive discharge
- (i) Wastes should be discharged under sea-level.
- (ii) Wastes should be dumped while the ship is proceeding.

(3) Basic direction of tentative standard of judgement on content of noxious substances is shown in the Appendix.

(5) Dumping areas are classified into 5, i. e. , A, B, C, D, and E, of which A, B and C areas are shown in the chart. Following are the basic standards for classification:

(i) Dumping areas for diffusible wastes excluding wastes containing noxious substances:

a. Fishing grounds and the living environment for marine products should be excluded.

b. Wastes should not be discharged in the vicinity of main ocean currents such as Kuroshio and Oyashio in order not to spoil the purification capacity of the sea.

c. Wastes should not drift ashore.

(ii) Dumping areas for settling wastes excluding wastes containing noxious substances:

a. Wastes should not be discharged in the vicinity of main ocean currents in order to prevent dispersion and settling of wastes in the bottom of the sea

b. Wastes should be dumped where the depth of sea is more than 1, 500 meters in order not to damage troll fishing nets.

c. Spawning grounds breeding grounds and main fishing grounds should be excluded.

d. Care should be taken not to give damage to submarine cables.

e. Wastes should be dumped at the distance as far as possible from main harbors.

f. Wastes should be dumped in the designated water areas (B-area) which are 20 nautical miles in width, taking the measuring and monitoring capacity of patrol boats into consideration.

(iii) Dumping areas for wastes containing noxious substances:

Dumping of wastes containing noxious substances shall be permitted only when they are concreted or enclosed with in durable vessels. Taking the possible damage of vessels into consideration, areas (A-area) shall be designated under the following conditions:

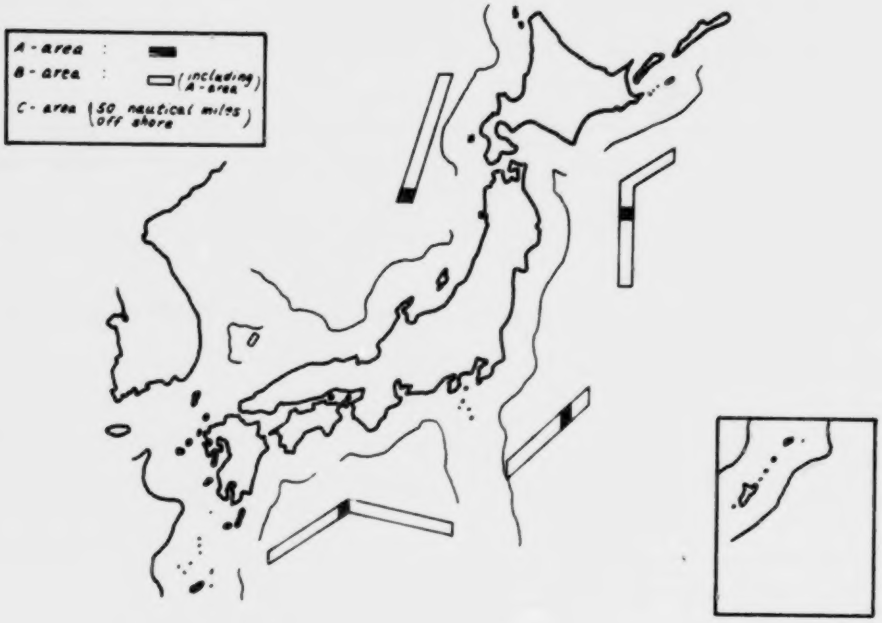
a. The bottom of sea should be flat so that there will be no danger of vessels being damaged by falling or rolling.

b. The depth of sea should be less than 6, 000 meters so that there will be no damage to vessels by water pressure.

c. The distance from main harbors should be even as much as possible.

d. The area should be smaller than B-area because stricter monitoring by patrol boats are necessary.

Chart of Areas for Ocean Dumping


A-area :
B-area : (including A-area)
C-area (50 nautical miles off shore)

Note:
(1) A-area and B-area are shown in the chart.
(2) C-area is the area which is more than 50 nautical miles off the seashore.
(3) D-area is the area which is with in 10 kilo meters from shore, excluding A, B and C areas; harbors designated by the Ports Regulation Law; and areas designated by the Minister of the Environment Agency.
(4) E-area is the area excluding those designated by the Minister of the Environment Agency.

Appendix 2

Basic line of tentative standard of judgment on the content of noxious substances

This summary report is related to the method of examining the noxious substances contained in the wastes and also the basic consideration on judging the noxiousness of the wastes.

And, this excerpt is a summary of the consideration relative to the standard of judgment especially on the disposal of the wastes into the seas or the "ocean dumping".

1. Environmental pollution caused by heavy metals contained in the wastes and influence on human health

It is generally through the medium of air, water and soil that heavy metals affect the human health as noxious substances and hinder the conservation of the living environment.

It would be ultimately done through either polluted water or food that the heavy metals contained in wastes affect adversely the health of human being.

2. Relation between heavy metals contained in the natural world and environmental pollution

Part of heavy metals are all continually circulating within the rock, water or life spheres. The microanalysis technology on heavy metals have made so great an advance today, that the smallest amount of heavy metals, which have hitherto been considered totally absent, may be detected in the human body, in the animal body and vegetables on which man lives, and also in the environments surrounding them. This, however, does not immediately mean that it has been caused by the environmental pollution.

The values of the heavy metals detected in environments, to be discussed in this report are not to be classified in terms of the technique of analysis into the "value in natural state" and the "value by pollution". It is necessary to know their background values - that is, to know the values of heavy metals contained in the environments, in natural or ordinary state, and also the forms these heavy metals take. Whether the environments, is polluted or not should be determined by comparing these two different values.

3. Consideration on the setting up of a standard of judgment

1) In order to make a judgment on the way of disposal, in relation to the environment of the place where the wastes are disposed. it is essential that the case of ocean dumping and the case of filled-in disposal of the wastes are judged

separately. A standard of judgement by different method should be established with regard to each of them.

2) The ocean dumping is divided into two, one is the "diffusion" type and the other is the "concentration" one.

3) The diffusion type ocean dumping is applicable to the disposal of an easily resolvable materials such as the sewage sludge, acid and alkali. Most of the heavy metals contained in these wastes are considered to be dispersed in the seas by diffusion and decomposition.

   As to noxiousness of these matters, therefore, a standard is to be set on the assumption that the heavy metals contained in them are entirely dissolved.

4) The concentration type ocean disposal is applicable to the disposal of mud and slag with high sedimentation property. These wastes are apt to settle and heap at the bottom of the deep seas. In setting the standard of dudgment, it is necessary to take into consideration of the component heavy metals at the bottom of the deep seas.

5) When noxiousness of the wastes is measured by the premises mentioned above, the judgement will be based on the standard of environment affected by water pollution or the standard of water for the marine production.

3. COMPREHENSIVE BASIN PLANNING

3-1 System of Comprehensive Basin Planning Study

Water pollution in public water bodies such as rivers, lakes and sea is caused by sewage discharged in a number of municipalities within a basin, and it is generally the case that the damage of water pollution likewise covers a number of their administrative districts. The policy for water quality conservation should therefore be enforced in an orderly and efficient manner under an extensive administrative control within an entire basin.

For this reason, the following measures should be taken so as to assure that the environmental water quality standards will be fully complied with.

(1) Stricter restriction over effluents.
(2) Improvement and provision of various pollution control facilities including sewage treatment plants.
(3) Adequate land use and appropriate location of the facilities.
(4) Improvement of river flow.
(5) Improvement of the surveillance and measurement system.
(6) Development of waste treatment technology.
(7) Financial support to local government.

These measures will produce no appreciable effect if implemented separately. To attain the desirable target therefore all these measures should be put in force in an integrated manner by the joint efforts of the national government, local governments and waste dischargers on the basis of a macromatic and long-term prospect for the entire basin.

Of the above-listed measures, that for the sewerage system is intended for improving the facilities for purifying various kinds of sewage discharged as a result of urban life and activities. In this connection, the environmental water quality standards are not achieved without the sewerage improvement.

Under these circumstances, the Sewage Law was revised in 1970, whereby it became obligatory to establish a comprehensive basin sewerage program for rivers and other public water bodies to which the environmental water quality standards are applied.

3-2 Process of Study

As explained at length at First US/Japn Conference on Sewage Treatment Technology (UJSTT) comprehensive basin sewerage study program is the fundamental program indeed, on the one hand, for satisfying the environmental water quality standards with a minimum of cost and time, and aimed, on the other, at mapping out

the ultimate and optimum sewerage system in respective basins.

The survey for the plan should therefore make for forecasting all the elements bearing upon water pollution in respective basins.

The process of study is as illustrated below.

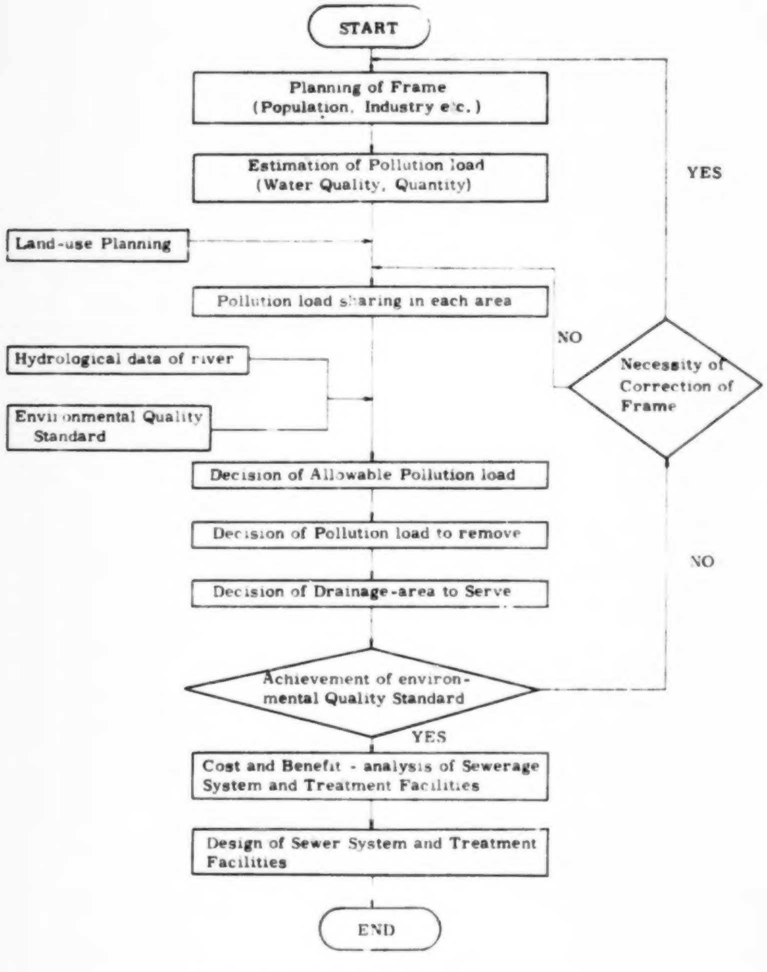

START
Planning of Frame (Population, Industry etc.)
Estimation of Pollution load (Water Quality, Quantity)
YES
Land-use Planning
Pollution load sharing in each area
NO
Necessity of Correction of Frame
Hydrological data of river
Environmental Quality Standard
Decision of Allowable Pollution load
Decision of Pollution load to remove
NO
Decision of Drainage-area to Serve
Achievement of environmental Quality Standard
YES
Cost and Benefit - analysis of Sewerage System and Treatment Facilities
Design of Sewer System and Treatment Facilities
END

Fig. 3-1. Flow-chart of Planning

3-3 General Description of respective Basin

The survey for comprehensive basin sewerage study program is planned to be conducted successively in respective basins in the order of the degree of water pollution. The survey was initiated in 1971, and the number of survey basins including those designated for 1973 survey totals 47.

Table 3-1 shows the survey basins and other particulars by year.

Table 3-1 - Survey Basins Covered by Comprehensive Basin Sewerage Study Program

Year of Survey	Survey Basin	Surveying Prefectural Government
1971	Ishikari R.	Hokkaido
	Edo R.	Chiba
	Naka R.	Saitama
	Sakai R.	Kanagawa
	Toyo R.	Aichi
	Oyabe and Sho R.	Toyama
	Kako R.	Hyogo
	Ota and Seno R.	Hiroshima
1971 - 1972	Yodo R.	Osaka, Kyoto, Shiga and Mie
1972	Tokachi R.	Hokkaido
	Abukuma R.	Miyagi and Fukushima
	Shinano R.	Niigata and Nagano
	Kasumigaura Lake	Ibaragi
	Kinu and Omoi R.	Tochigi
	Sagami R.	Yamanashi
	Jintsu R.	Toyama
	Kiso R.	Gifu
	Shonai R.	Aichi
	Harima Sea	Hyogo
	Tenjin R.	Tottori
	Hii R.	Tottori and Shimane
	Kojima Lake	Okayama
1972 - 1973	Osaka Bay	Osaka and Hyogo
	Tokoro & Abashiri R.	Hokkaido
	Akita Bay	Akita
	Mogami R.	Yamagata
	Naka R.	Ibaragi and Tochigi
	Tone R.	Chiba, Ibaragi, Tochigi,
	Kaname R.	Kanagawa
1973	Ashi Lake and Haya R.	Kanagawa

	Tenryu R.	Nagano
	Sai and Ono R.	Ishikawa
	Kano R.	Shizuoka
	Hamana Lake	Shizuoka
	Ibi and Nagara R.	Gifu and Mie
	Yokkaichi and Suzuka	Mie
	Kuzuryu R.	Fukui
	Kino R.	Wakayama and Nara
	Chiyo R.	Tottori
	Asahi and Yoshii R.	Okayama
	Ashida R.	Hiroshima
	Sea Area of Otake and Iwakuni	Hiroshima and Yamaguchi
	Yoshino R.	Tokushima
	Sakaide and Marugame	Kagawa
	Shigenobu R.	Ehime
	Urato Bay	Kochi
	Oyodo R.	Miyazaki
Total	47 basins	

3-4 Problems to be discussed

The past survey activities brought to the fore a number of problems which demanded reexamination of the survey method by new approaches.

(1) Run-off Ratio

One of the problems is the variation coefficient of the pollution load before it reaches the bench mark station in a river, i.e., the run-off ratio. The run-off ratio can be broadly classified into the concentration ratio of the polluted matter to rivers and the reduction (purification) ratio in rivers. Since the value of the run-off ratio largely affects the size of sewerage service area required for fulfilling the environmental water quantity standards, it should be determined after a careful survey of the basin.

To cope with the case where no data are available for studying concentration and purification ratios separately, the following equation was employed during the last year's survey. This calculation method is planned to be introduced in the coming years with efforts made for improving its accuracy.

$$\sum_{i=1}^{n} (q_{1i}C_1 + q_{21}C_2)\ 10^{-kti} = W_j$$

where, W_j : Pollution load measured at the j-th bench mark station.
q_{1i} : Pollution load generated in the i-th urbanization area.
C_1 : Concentration ratio of q_{1i}.
q_{2i} : Pollution load generated outside the ith urbanization area.
C_2 : Concentration ratio of q_{2i}.
t_i : Time of concentration from point i to the bench mark station.
K : Purification constant.

By the application of the above equation, the values of C_1, C_2 and K can be simultaneously obtained if there are three or more bench mark stations (j) for pollution load measurement. Even in case there are only two bench mark stations, the values of C_1, C_2 and K can be obtained by repeating calculation until assumptive values at the two points come to coincide with each other.

In the case of the Toyo river basin, trial calculation based on the measurements at Ishida and Touko stations led to the acceptable values of

$C_1 = 0.75$, $C_2 = 0.3$ and $K=0.046$. However, since the values thus obtained present noticeable discrepancies even within the urbanization area, the urbanization area should be divided into smaller sections according to the degree of urbanization so as to attain a higher accuracy of calculation.

(2) Allocation of Allowable Pollution Load between municipal and industrial wastes.

Next comes the problem of allocating each discharging source to the reduced pollution load which is below the limit of allowabel load.

Though the comprehensive basin sewerage study program is essentially a sewerage construction plan intended to satisfy the environmental water quality standards, it should incorporate the control over industrial waste water and other water quality conservation policies so that the water quality standards as a whole may be satisfactorily complied with.

For this purpose, the required reduced pollution load should be allocated to each discharging source by the ratio of discharged pollution load, and the sewerage service area should be delineated according to the pollution load reducing method adopted by respective discharging sources.

This allocation plan is based on the principle of the discharger's responsibility for conserving water quality in public water bodies, and presupposes that the pollution load of domestic waste water will be maintained at the required level by the relevant sewage works offices and that of industrial waste water by the industries themselves through effluents standard regulations. Insofar as industrial waste water is concerned, therefore, the pollution load to be reduced by respective dischargers should be indicated explicitly in figures under the effluent standard regulations.

(3) Determination of Treatment Efficiency

The third of the problems is the efficiency of sewage treatment plants.

The sewage, treatment has chiefly resorted to the activated sludge method over the past years. The 1972 survey disclosed, however, that water pollution is in rapid progress and that the environmental water quality standards can no longer be satisfied by the secondary treatment in many areas. Hence, it is planned that the tertiary treatment method will be positively introduced in the coming years.

If the tertiary treatment method is to be applied, however, the installation of treatment facilities in the basins with a coastline becomes a problem. In other words, if all the patterns call for the tertiary treatment, then comparative study should be made between the sewage discharge into rivers embraced by the present plan and the discharge into open sea. Needless to say, the environmental water quality standards for rivers can be fulfilled if all the sewage generating in the basin is discharged into the sea, but the formulation of the plan cannot be regarded as completed unless the water quality in the sea outside the river basin is forecast and checked if it meets the environmental standards. Hence, it will become essential to take sea areas into consideration in formulating a sewerage plan if the basin in view has a coastline, but this should be studied separately as the problem of selecting the sewerage service area. If all the patterns demand the tertiary treatment in the sewerage study program, then the cost comparison should be made for selection of the optimum pattern on the assumption that the tertiary treatment will also be employed for sewage discharge into open sea.

(4) Scheduling of Project Implementation

The fourth and last of the problems is how the work schedule up to the target year of attaining the environmental water quality standards should be planned.

It is anticipated that the sewerage service ratio in respective municiplaities will naturally vary by the water quality measured at the bench mark stations. Further, in the case of an extensive installation plan such as the regional sewage works scheme, the implementation cost will vary to a substnatial extent by the distance from each municipality to the trunk sewers and treatment plants. For these reasons, the priority order of work should be determined for each municipality, but this should be preceded by the determination of the required sewerage service area of each municipality.

In the calculation method explained below, the scale of sewerage service required to satisfy the environmental water quality standards is so assumed that the required reduction ratio at respective bench mark stations will yield the maximum cost-benefit ratio for the municipalities involved.

$$\sum_{i=i}^{n} Y_i = \sum_{i=1}^{n} \left(\frac{S_i X_i}{P_i + C_i A_i X_i} \right) \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$L = \sum_{i=1}^{n} L_i X_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where,

Y_i : Benefit ratio of each municipality.

L : Required pollution load reduction ratio at the bench mark station (t/day).

L_i : Pollution load generated from each municipality (t/day).

S_i : Volume of sewage generated from each municipality (m^3/day).

X_i : Load reduction or sewerage service ratio by municipality.

P_i : Installation cost of the trunk sewer laid to the municipality and of the treatment plant (million yen).

A_i : Swerage service area by municipality in the final year of the project (ha).

C_i : Sewerage service cost per ha (million yen/ha).

The value of X_i should be such that makes the value of $\sum Y_i$ the maximum. However, a basin sewerage study program usually embraces two or more municipalities and as a consequence, the two equations shown above involve too many unknown factors and cannot be solved as they are. Therefore, the differential of the benefit ratio Y_i to the service ratio $X_i(d\ Y_i/dX_i)$ should be obtained at first, then the differential for a certain selected dX_i, e.g., service ratio varied at intervals of 10%, should be selected from larger values until X_i which satisfies equation (2).

The calculation method explained above is just an example and does not apply to all cases. Studies should therefore be made in future to devise a suitable calculation method. However, whatever method may be adopted in future, it is necessary to determine the area to be served by the sewerage system in the final project year in the first place, and then decide upon the priority order with account taken of the present service ratio, cost, municipal financial status, etc.

In the above items, some problems raised by the past survey activies are introduced with attempts made for their solution. Besides the problems cited above, there are many others such as the water quality calculation in sea areas and tidal zones where the survey activities are expected to be augmented, method of calculating the required reduction of non-BOD loads, e.g., nitrogen and phosphorus loads, and method of reducing such loads. The problem of fundamental importance, however, is that of the pollution load reduction required for complying with the environmental water quality standards, and this can be translated to the relationship among the regional development plan, the required sewerage service ratio and effluent control over industrial wastes. As described earlier, pollution loads are considered to have originated chiefly from domestic sewage and industrial waste water, and the survey is conducted to predict the future values of such loads from the future population and industrial shipments estimated on the basis of regional development plans. In certain limited cases, this survey method produced a result which indicated that the implementation of measures for satisfying the environmental water quality standards is almost impossible to achieve under the current administrative control. These rare cases were invited by the error involved in the values adopted in the plan. In other words, the environmental quality standard adopted in such a plan was just too high in comparison with the actual state of pollution, or the scale of sewerage service envisaged by such a plan was determined without giving due consideration to the actual pollution load.

The major task to be undertaken in the future survey activity will be to establish regional development plans which can be justified from the viewpoint of environmental water quality conservation.

4. PROGRESS AND PLANS FOR SEWAGE WORKS IN JAPAN

4-1 The Target of Third Five-Years Plan for Sewage Works

The Third Five-Year Plan for Sewage Works was framed under the provisions of the Law concerning Urgent Measures for Sewerage Service and put into action by Cabinet Order on August 27, 1971.

The plan was drafted to cope with the aggravation of urban environment and pollution of public water bodies invited by the delay in sewerage service. It aims at improving urban environments and conserving water quality in public water bodies through systemtatic and rapid improvement of the sewerage system which is one of the fundamental urban facilities. For this purpose, a total of 2, 600 billion yen is expected to be invested over a five year period from 1971 to 1975.

Under the Five-Year Plan, sewage works in the selected project areas, particularly in basin areas, are planned to be accelerated on the basis of the Comprehensive Basin Sewerage Study Programme which was formulated to meet the environmental water quality standards established under the Basic Law for Environmental Pollution Control.

The cost breakdown and improvement prospect envisaged by the Five-Years Plan are as tabulated below.

Table 4-1 Cost of the Third Five-Years Plan for Sewage Works

Unit: Million yen

Classification	Total Cost	Cost of Subsidized Sewage Works		Cost of Non-subsidized Sewage Works	
	A	B	B/A	C	C/A
Public Sewerage System	2, 030, 000	1, 157, 470	57. 0%	872, 530	43. 0%
Regional Sewerage System	360, 000	324, 000	90. 0	36, 000	100. 0
Storm Sewer	80, 000	80, 000	100. 0	0	0. 0
Specified Public Sewerage System	30, 000	25, 530	85. 1	4, 470	14. 9
Reserve Fund	100, 000	-	-	-	-
Total	2, 600, 000	1, 587, 000	63. 5	913, 000	36. 5

Table 4-2 Prospect of Improvement Envisaged by Five-Years Sewerage Improvement Plan

Item		1970	1975
Urban Area	(km^2) A	5, 945	8, 490
Population of Urban Area	(10, 000 persons) B	6, 280	7, 540
Sewerage Service Area	(km^2) C	1, 354	3, 220
Service Population	(10, 000 persons) D	2, 180	4, 140
Capacity of treatment facilities	(") E	2, 204	5, 367
Ratio of Sewerage Service Area	(%) C/A	22. 8	38. 0
Ratio of Service Population	(%) D/B	34. 7	55. 0

4-2 Problems Entailed in the Past Programs

Up to 1972 which is the second year of the Third Five-Year Plan, about 28% of the total project cost was spent but the amount of works done reached only about 17% (due to increased construction cost).

This is considered attributable to the following reasons.

1) Increased application of special construction methods (such as shield driving method and tunnelling method).
2) Increased construction work during nighttime
3) Need for countermeasures against construction nuisance (noise, burried pipes such as gas, water etc.)
4) Expensive investment for sludge disposal
5) Need for environmental improvement through provision of covers for tanks ordor prevention and beautification of sewage treatment facilities.
6) Rise in the material price, labour cost and land cost.

4-3 Long-term Prospect for Sewage Works

Considering the increasing demand for water ensued from economic growth, need for complying with the environmental water quality standards and demand for improving the living environments in the expanding urban areas, it is imperative that the sewerage service will be accelerated and prompted in future.

With the view to meet all these demands and requirements, the following objectives are planned to be attained by the future sewage works.

1) Provision of the sewerage system in rural and fishing villages and sightseeing places as well as in urban areas to raise the coverage of public sewerage system to 100% in inhabited areas and 90% for the total population by 1985.

2) Accelerated improvement of regional sewerage systems on the basis of the Comprehensive Basin Sewerage Study Programme for early attainment of the environmental water quality standards.

3) Promotion of tertiary treatment and reuse of treated sewage for water quality conservation and effective water utilization.

4) Augmented installation of the separate sewerage system, improvement of existing combined sewerage systems, and capacity increase of existing plants.

5) Expansion and improvement of sludge treatment facilities to meet the stricter standards for sewage sludge disposal, and promotion of extensive sludge disposal system.

6) Attainment of environmental harmoney between the sites of sewage treatment plants and surrounding areas by constructing parks or other facilities according to the local condition with covered sewage treatment plants.

The total fund to be invested from 1971 to 1985 to attain the above-listed objectives is estimated to amount to approximately 31,000 billion yen (in 1970 material price).

5. FINANCING OF SEWAGE WORKS IN JAPAN

5-1 Introduction

Sewage works in Japan have long been regarded as a part of municipal activities and the national government's concern for their improvement has been rather limited until very recently.

Sewerage system, however is one of the fundamental urban facilities which can never be dispensed with for maintaining satisfactory living environments in urban areas, and exhibits multiple functions such as storm drainage, drainage of low-lying marshy areas, sewage and night soil treatment, water quality conservation in public water bodies, etc. Its influenced area is not limited to the drainage area where the improvement in living environments can be directly enjoyed, but also embraces extensive downstream or coastal areas of public water bodies whose water quality is conserved by the improvement of sewerage system. In this connection, sewerage system has a highly public nature.

Today, sewerage system is given even higher public nature than before by reason of the pressing need for improving it for pollution prevention in public water bodies and quality conservation of water resources. Sewerage improvement is now one of the fundamental public works which should be prompted from the national viewpoint for conservation and recovery of natural environments as well as for socio-economic development based on an adequate national land use plan.

It cannot be denied, however, that sewerage system has an aspect which calls for its management by public enterprises. This is due to the fact that the relationship between the sewerage operators and respective parties exercising rights in the area covered by the sewerage is rather individual than comprehensive in the disposal and treatment of sewage discharged as a result of activities of inhabitants and enterprises.

The recent several years have seen the growing government's recognition of the importance of sewerage improvement, and this has been accompanied by the augmented demand for establishing a better and more effectual financial system on the basis of the social functions currently performed by sewerage system.

5-2 Fundamental Concept of Financial Sharing

The fundamental concept of financial source for sewage works in Japan was presented in the reports of the first and second Committee for Reviewal of Sewerage Financing held in 1960 and 1966 respectively by Japan City Center (established by the contribution from National Association of Mayors) at the request of the Ministry of Construction.

The concept, as summarized from the report of the first Committee and the second Committee, is as follows.

1) Cost required for sewage works comprises the construction cost and the operation and maintenance cost.
2) Each cost can be divided into two portions, i. e. , the public-borne portion which is to be covered by tax revenues and the privately borne portion to be covered by specific individuals. The publicly borne portion can be further divided into two subportions, one to be borne by the national government and the other by the local municipality which undertakes the sewage works.
3) Division of the cost into public and privates expenses is to be made by whether there exist any individual relations between the benefit of public sewerage service and respective users of public sewerage system.

The benefit derivable from public sewerage service consists in the drainage of storm water, and drainage and treatment of sanitary sewage. In the case of storm water drainage, its benefit cannot be clarified for each user of the sewerage system and therefore, the cost should in principle be borne publicly, provided, however, that a portion of the cost should be borne privately to the extent that the benefit is enjoyed by specific land owners and users in the form of increased land value or others. In the case of drainage and treatment of sewage, the greater part of benefit can be clarified for each user but a portion of the benefit is exhibited by water quality conservation in public water bodies and improvement of general urban environments. Hence, the cost for yielding the former benefit should be borne privately and the cost for the latter benefit should be borne publicly. The publicly borne portion of the cost of sewage treatment is considered approximately equivalent to the privately borne portion of the cost of stormwater drainge. As a whole, therefore, it is practicable to assume that the cost of sewage treatment is borne privately and that of stormwater drainage is borne publicly. At the second Committee, it was estimated that the sewage treatment cost and stormwater drainage cost occupy 30% and 70% respectively in the total construction cost, while the two costs account for 70% and 30% respectively of the total operation and maintenance cost. Based on this estimate, the report states that 30% of the construction cost should be borne privately and 70% publicly, and that 70% of the operation and maintenance cost should be borne publicly and 30% privately.

4) The publicly borne portion of the cost is divided into two sub-portions, one to be borne by the national government and the other by the local municipality undertaking sewerage service. One half of the construction cost which is large and need to be invested concentrically should be borne by the national government in view of the fact that 1) public sewerage is one of the fundamental urban facilities whose improvement should be enhanced for national interest and 2) there is acute need for enacting extensive preventive measures against pollution of public water bodies without regard to municipal or prefectural boundaries. The local municipality undertaking sewerage service should cover the remaining one half of the public borne portion of construction cost as well as the 30% publicly

borne portion of operation and maintenance cost.

5) The financial sharing stipulated above should be covered as described below.

a. That part of public-borne portion of the construction cost which is to be disbursed by the national government should be covered by the national government subsidy granted each year to the local municipality undertaking sewerage service.

b. That part of public-borne portion of the construction cost which is to be disbursed by the local municipality should be covered by the general revenue and national loan of that local municipality.

c. The private-borne portion of the construction cost should be covered by the special assessment [1]. In case the amount collected from the beneficiaries falls short of the private-borne portion, the local municipality should cover the balance temporarily for refundment by the collection of sewer charges whose calculation basis is so determined as will include both principal and interest of the said balance.

d. The public-borne portion of the operation and maintenance cost should be disbursed from the general revenue of the local municipality, and the private-borne portion should be covered by the collected sewer charges.

e. Accordingly, the sewer charges collected from beneficiaries cover the private-borne portion of the operation and maintenance cost and that part of the private-borne portion of the construction cost which is advanced temporarily by the local municipality.

The tariff of sewer charges should be based on the actual state of sewerage utilization with account taken of the quantity and quality of sewage.

The following is an example of calculation system based on quantity.

Sewage Charge per m^3 =

$$\frac{\dfrac{\text{Construction Cost} - \text{National Government Subsidy} + \text{Special Assesment} + \text{Interest on National Loan}}{\text{Durable Years}} \times 0.3 + \text{Annual Operation Maintenance Cost} \times 0.7}{\text{Annual Total Sewage Volume } (m^3)}$$

f. That part of the construction cost to be disbursed from the general revenue of the local municipality (i. e., the portion not covered by national loan), principal and interest of national loan to be refunded from the general revenue, and that part of the operation and maintenance cost which should be borne by the local municipality are to be included in the standard requirement of local allocation tax. 2)

6) The concept of special assessment described in Items 1) to 5) above is applicable to the ordinary sewage works but not to the following specific cases.

a. Construction cost of regional sewerage system 3)

Regional sewerage system constitutes the main trunk sewer and treatment plant of the extensive sewerage system designed to produce far-reaching service effect over a wide area. Since its construction yields benefit for specific individuals after a substantial time lag, it is not practicable to charge part of the construction cost to the beneficiaries.

Accordingly, the construction cost should be borne by the national government and the relevant local municipalities. The government's financial share in this case should be larger than is set for public sewerage system, because the regional sewerage need to be improved over a wide area as a part of regional development prior to the creation of cities. The rest of the cost should be borne by the prefectural governments undertaking the construction work, with some fractions of it charged to the corresponding municipalities because they will not be required to install their own sewage treatment plants.

(Since the second committee was held in 1966 when the regional sewerage was still new and in the initial stage of construction, the committee's report does not touch on the financial share in the operation maintenance cost)

b. Financial share of dischargers of strong waste

The sewer charges to be collected from the dischargers of strong waste including industrial waste water which incurs higher treatment cost than domestic sewage should be determined with account taken of not only the sewage quantity but also its quality.

c. Construction cost of public sewerage system in new town

In case a private developer undertakes the construction of a public sewerage system in a substantially wide area in parallel with its residential land formation work, the municipality which is to take charge of the operation and maintenance of the system should provide the said developer with subsidy covering a part of the construction cost, and the national government should grant subsidy to such municipality according to the established standard.

5-3 Setup of Current Sewerage Financing System

The current sewerage financing system in Japan briefed below conforms generally, though it is not perfectly done, to the idea advanced in Section 5-1.

5-3-1 Public Sewerage System

1) Construction Cost

a. Construction of trunk sewers and sub-main sewers, sewage treatment plants, and pumping stations and other facilities performing supplementary functions is called the subsidized sewage works, and all the other kinds of sewage works are called the non-subsidized sewage works. The former accounts for about 57% of the entire public sewage works carried out in the country, and 40% of its cost is covered by the national government subsidy.

b. 50% of the cost of subsidized sewage works remaining after deducting the national government subsidy and 80% of the cost of non-subsidized works are covered by the national loan 4).

c. The special assessment is appropriated to cover 1/3 to 1/5 of the construction cost.
The special assessment system was in effect in 209 out of a total of 279 municipalities which undertook public sewage works during 1971. In those cities where the special assessment system was not employed, the amount which could otherwise be collected from beneficiaries was disbursed from the municipal general account.
However, since the special assessment is reduced or exempted for sewage works in areas accommodating public facilities such as road, park etc., the total collected amount is less than 1/3 to 1/5 of the construction cost and equivalent to about 10% of the total project cost.

d. Additional fund requirements not covered by the above-mentioned funds is met by disbursement from the general revenue of the local municipalities concerned. This disbursement is made by transfer from the general account to the special account which is required to be established for defrayment of all the expenses of public sewage works in each municipality.

The sources of general account for public sewage works comprise the local tax revenues including the city planning tax, property tax and local allocation tax. The city planning tax is an object tax collected by municipalities for appropriation for city planning works. The appropriation rates of this tax for construction of parks and roads and other city planning works are not determined. Consequently, no definite rate is set either for appropriation for public sewage works. The local allocation tax is distributed among local governments as a source of their general account without designating its application, but the amount distributed by the national government usually meets the standard financial requirement submitted by respective local governments. In this sense, the standard requirement for local allocation tax bears closely upon the amount which can be transferred from the general account for public sewage works. The standard financial requirement prepared by the local governments therefore includes the item for public sewage works under which is entered the amount close to the cost to be actually covered by the general account.

2) Operation and Maintenance Cost

The operation and maintenance cost is covered by the sewer charges and general account. Sewer charge system are taken in almost all municipalities covered by public sewerage system. In most cases, the charges are collected on the basis of sewage quantity at a rate of 5 to 20 yen per m^3 which is hardly enough to cover the sewage treatment portion of the operation and maintenance cost.5) Sewage quality is not taken into account in determining the charges except in few municipalities.

The public-borne portion of the operation and maintenance cost is included in the standard requirement of local allocation tax.

5-3-2 Specified Public Sewerage System

In case two-thirds or more of sewage inflow volume into a public sewerage system is industrial waste water, such system is called the specified public sewerage system. The financial shares in the construction and operation cost of such system differs from the case of ordinary public sewerage system as described below.

1) Construction Cost

In case of the enterprise which commenced its business activities in or prior to 1970, 1/4 of the total construction cost is borne by the enterprise, 1/3 of the remaining 3/4 (i. e., 1/4 of the total cost) by the national government subsidy, 1/2 of the remaining 2/4 by the fund raised by national loan, and the remainder by the general account of the local municipality.

In case of the enterprise which started its activities in or after 1971, the enterprise bears 1/3 of the total construction cost or its share in the total cost as calculated under the provisions of the Law concerning the Entrepreneurs' Sharing in the Cost of Environmental Pollution Control Works 6).

Financial sharing in the remaining 2/3 of the cost are divided in much the same manner as described above.

Special financial sharing imposed on the enterprise is one of the application patterns of the principle of the discharger's responsibility for pollution control. In view of the increasing quantity and pollution load of industrial waste water, the financial sharing of enterprises was raised from 1971. However, this share is determined by an agreement concluded between the enterprise and the local municipality except when it is collected under the Law concerning Entrepreneur's sharing in the Cost of Environmental Pollution Control Works.

2) Operation and Maintenance Cost

This is covered by the sewer charges and general account of the local municipality. In all cities offering the service of industrial waste water treatment in 1971, the greater part or whole of this cost is covered by the sewer charges.

5-3-3 Regional Sewerage System

1) Construction Cost

About 10% of the total construction cost is borne by specific enterprises and other fund sources, and one half of the remaining cost is covered by the national government subsidy and another half is equally borne by the prefectural government and the corresponding municipalities involved.

The amount borne by the municipalities is paid to the prefecture as their sharing. Division of this share between municipalities is made according to the area planned to be covered by the corresponding public sewage system and the design sewage quantity.

60% of the cost borne by the prefecture and municipalities involved is covered by the fund rasied by national loan, and the remainder by the general account.

The cost which can be justifiably charged to specific enterprises is included in the sharing of the municipality undertaking the corresponding public sewerage service and paid to the prefecture. The cost thus advanced by the municipality is recovered later by collection of sewer charges.

The cost covered by the general account is included in the standard requirement of local allocation tax.

2) Operation and Maintenance Cost

Since the regional sewerage has not entered the stage of full-scale operation yet, the sharing in its operation and maintenance cost are determined by consultation between the corresponding municipalities involved and the prefectural government and not by a definite standard.

5-3-4 Public Sewerage System in New Urban Areas

The developer of a newly created urban area is obliged to construct public sewerage system. In this case, 60% of the cost of sewer pipes is borne by the developer and the remaining 40% is covered by the national government subsidy. With the exception of this provision, the cost allocation is the same as in the case of ordinary public sewerage system.

To alleviate the financial burden on the local municipality, however, it is allowed to make arrangements between the developer and the local public body so that the former will bear the total cost at the outset and the latter will refund its share in the cost to the developer at a later date. If such arrangements are made, refundment to the developer is made by the national government subsidy, fund raised by national loan and disbursement from general account of the municipality.

Beneficiaries's special assessment is not collected since it is included in the sales price of the developed residential land.

Sharing in the operation and maintenance cost of the completed sewerage system after its delivery to the municipality are divided in much the same way as described in Section 5-3-1.

5-3-5 Summary of Prevailing Financial Shering

The financial sharing in the construction and operation cost of sewerage system currently in force can be summarized as shown below.

Construction Cost

	Public Sewerage System	Public Sewerage System in New Urban Areas	Specified Public Sewerage System	Regional Sewerage System
National Government Subsidy	0.57 x 4/10	Cost of Treatment Plants x 0.9 x 4/10	3/4 x 1/3 (before 1970)	0.9 x 1/2
		Cost of Sewer x 0.4 x 4/10	2/3 x 1/3 (after 1970)	
National Loan	0.57 x 3/10	Cost of Treatment Plants x 0.9 x 3/10	3/4 x 2/3 x 1/2 (before 1970)	0.9 x 1/2 x 0.6 (Equally borne by prefecture and municipalities)
	0.43 x 8/10	" x 0.1 x 8/10	2/3 x 2/3 x 1/2 (after 1971)	
		Cost of Sewer x 0.4 x 3/10		
Beneficiaries' Special Assessment	1/5 - 1/3			
Entrepreneur's Share	-	-	1/4 (before 1970) 1/3 (after 1971)	
Developers' Share	-	Cost of Sewer Pipes x 0.6		
General Municipal (Prefectural) Account	Remainder of above.	Remainder of above.	Remainder of above.	Remainder of above.

Operation and Maintenance Cost

	Public Sewerage System	Public Sewerage System in New Urban Areas	Specified Public Sewerage System	Regional Sewerage System
Sewer Charges	Amount Collected	Amount Collected	Amount Collected	-
General Municipal (Prefectural) Account	Remainder	Remainder	Remainder	Shares in the cost determined by consultation between the parties concerned

Cf: (1) Since the national government subsidy is granted to cover a specific portion of the construction cost, its percentage in the total construction cost averages 22. 8% (1971).

(2) Beneficiaries' share is reduced or exempted for construction of sewerage facilities in public-owned land such as road, park etc. Hence, its percentage in the total construction cost averages about 10%.

(3) The average of the sewer charges collected in 150 municipalities accounted for 57. 7% of the operation and maintenance cost of public sewerage system in 1971.

The total cost of public sewage works (including regional sewage works) undertaken by all the local public bodies and its allocation by source in 1971 are as shown below.

Unit: 100 million yen
(Figures in parentheses: %)

	Total	Fund Source							Sewer Charges
		National Government Subsidy	Local Funds						
			Total	National Loan	City Planning Tax	Special Assessment	Prefectural Fund	General Revenue	
Construction Cost	3, 522 (100)	915 (26. 0)	2, 607 (74. 0)	1, 750 (49. 7)	46 (1. 3)	67 (1. 9)	57 (1. 6)	687 (19. 5)	-
Operation & Maintenance Cost	444 (100)	-	189 (42. 6)	-	-	-	-	189 (42. 6)	255 (57. 4)
Bond Redemption	518 (100)	-	518 (100)	-	-	-	-	518 (100)	-

5-4 Problems of Current Sewerage Financing System

The current financing system is based on the fundamental concept that factors of both public works and public financial corporation are involved in sewage works. The beneficiaries' share arises from the latter, i. e., the public enterprise nature of sewage works.

However, due to the rapid urbanization and increasing pollution of public water bodies, Japan is pressed hard for improvement of public sewerage system. Over the past years, therefore, the public nature of sewage works has been increasingly intensified, and this in turn called for larger public-borne portion in the total project cost. Considering the urgency of the situation and the resultant heavy financial burden on local governments, it leaves little doubt that the national government's a share in the seweage service cost should be augmented to a large extent. Account must also be taken of the fact that the increasing discharge of industrial waste water is one of the causes of rising cost of sewage works. Measures should be taken for charging a substantially large portion of the cost to industrial waste water so that no financial inequality will be incurred on domestic households and enterprises to which the Water Pollution Control Law is applied.7)

The situation calls for the reexamination of financial sharing in the cost of sewage works. Division of public-borne portion and private-borne porition and the shares of the national government and local municipalities in the public-borne portion should be put to reviewal. As for the private-borne porition, the principle of the discharger's responsibility for pollution control should be brought to the fore once again and equality in financial burden should be attained by the application of a suitable sewer charges collecting system.

The problem of financial sharing is also involved in the construction and operation of the regional sewerage system and corresponding public sewerage system which are the larger-scale public sewerages. To bring solution for this problem, studies should be made as to how the principle of financial sharing will affected by the 1) need for operating these extensive sewerage systems while maintaining coordination with the expansion of urban areas and utilizing receiving rivers as water resources and 2) necessity for improving sewerage systems prior to creation urban areas. On the basis of such studies, the public- and private-borne portions as well as the shares of the national government and pertinent local government in the public-borne portion should be made clear.

The Ministry of Construction is planning to request the Japan City Center to open the third Committee for Reviewal of Sewerage Financing for detailed discussion on the problems enumerated above.

5-5 Subject Matters for Discussion at the Third Committee for Reviewal of Sewerage Financing

Subject matters planned to be discussed at the third the Committee for Reviewal of Sewerage Financing can be summarized as follows.

1) Considering the functions of sewerage and acute need for its service as well as the present status of financial sharing, is it not justifiable, as a rule, to have

the total construction cost borne publicly ?

2) A very large portion of the construction cost to be covered by local municipalities is raised by national loan. The principle and interest to be refunded, which is already very large, will impose heavy financial burden on local municipalities in future due to the rapid pace of sewage works. This present a sharp contrast to such other public works as road construction and river flood prevention for which substantially large subsidies are provided by the national government. Is it not necessary to raise the rate of national government subsidy in view of this fact ?

3) Progress of sewerage service entailes extreme rise in the cost of accepting and treating industrial waste water. Is it no justifiable to charge this cost to the discharging enterprises according to P. P. P. as an exception to the principle of public borne cost mentioned in Item 1) above ? If so, what would be the proper burden sharing and how the shares should be borne ?

4) The beneficiaries' special assessment is imposed on land owners and land users in areas covered by sewerage at present. Should this system be maintained as another exception to the principle mentioned above ?

5) As for the cost of operation and maintenance, it is considered that the past practice should be followed. In other words, sewer charges should be collected to cover the portion which directly produces user's benefit, and the remaining portion should be covered by the general account of local public bodies. To assure that the sewer charges will more accurately represent the user's benefit, it is believed essential that the quality-based charge system should be widely adopted in addition to the prevailing quantity-based system. What, then, would be the quality standards to be adopted for application of such quantity and quality-based system ?

6) Is it not necessary to establish a special public borne expenditure system to cover the cost of operation and maintenance in view of the anticipated high-level sewage treatment ?

7) In addition to above, what other improvements should be effected, in accordance with the aforementioned principles, to the financial sharing in the improvement cost of special sewerages such as regional sewerage system and specified public sewerage system ?

Notes:

1) Beneficiaries' Special Assessment

Under the provision of Article 75 of the City Planning Law (revised in

1968 and enacted in 1969), beneficiaries special assessment is collected from the persons receiving large benefit from city planning works and ensuring equality in financial burden on the inhabitants in the project area. Sewage works are carried out as part of city planning works in almost all cases. In areas covered with sewerage system, sewage and night-soil is possible to be removed and rain water can also be readily drained. Since inhabitants in such areas enjoy the benefit not confered in other areas, they are subject to the collection of beneficiaries' special assessment under the said law.

2) Local Allocation Tax

Each of local government is required to provide the inhabitants in its administrative district with services of the specified level irrespective of its financial capacity. For this reason, the national government preserves a certain fixed rate of national tax revenues as the common financial source of local governments, and distributes the same among local governments whose revenues fall short of expenditures to fill the gap between the two. This system is called the local allocation tax system.

Under this system, calculation of financial demand and income is of great importance. Particularly, accurate calculation of financial demand calls for the application of a highly technical and complex method. For objective and accurate calculation of financial demand, a unit for accurate measurement of financial demand is established under each administrative item and the cost per unit (unit cost) applicable to standard and representative organizations is obtained. Then, the number of units (measuring units) is adjusted by each local government because the difference in the number of measuring units makes the unit cost differ from that of the representative organizations. The product of the adjusted number of measuring units and the unit cost is the standard financial requirement.

The standard financial income covers only local tax income and incomes which go to the general account. Accordingly, the standard financial requirement does not include that portion of the total financial requirement which is covered by national government subsidy, service charges and other special revenues. In other words, it covers only that portion with which to cover the shortage of general account fund.

3) Regional Sewerage System

In case an urban area extends beyond the administrative boundary of a single municipality or the pollution of a receiving water body demands adjustment of sewage effluent from public sewerage system in the municipalities in the river basin, sewerage service should be effected in a wide area embracing two or more municipalities. When such sewerage system is completed, it is advisable that the prefectures take charge of its trunk sewer and the corresponding municipalities take care of the local sewer pipes connecting to the trunk sewer. The trunk sewer system controlled by prefectural government is called the regional sewerage system and the local sewer pipes taken care of by municipalities are called the relevent public sewerage system.

The regional sewerage system is thus large in scale, and its service is planned, by reason of its scale, on the basis of a longer urbanization prospect than is required for ordinary public sewerage system.

4) Approval System for National Loan

In Japan, local municipalities wishing to issue bonds are required to obtain the government's approval on the total amount, method of floatation, interest rate, etc. This approval system was established for the purpose of appropriate local financing, coordination between public fund requirement and private fund requirement, and adjustment of fund requirement between local governments.

For implementation of public sewage works, local municipalities are allowed to issue sewage bonds to raise the amount described in Section 5.

3/4 of the issued sewage bonds are accepted by the government and the remainder by the Public Financing Corporation, and private enterprises.

The following table shows the terms of loans floated in 1972.

	National Government	Public Financing Corporation	Banking Institution	Public Subscription
Annual Interest Rate	6. 5% (6. 2% on loans)	6. 7%	Determined by arrangement between local governments and accepting banking institutions	6. 8% (nominal rate)
Term of Redemption	30 years (Deferment term: 5 yrs)	23 years (Deferment term: 3 yrs)		10 years (Deferment term: 3 yrs)

5) Quality-based Sewer Charges Applied in Kobe City

(Kobe, Ukima (Tokyo), Kyoto, Nagoya, Gifu, Takarazuka and Tatebayashi)

The quality-based sewer charges calculated by the following rates are collected from the dischargers of strong waste water in addition to and within the limit of 5 times the ordinary sewer charges.

Pollution Load	Charges per m^3
Ordinary sewage (standard rate)	10 yen
F	
-1,000	Plus 5 "
1,000 - 2,000	" 10 "
2,000 - 3,000	" 15 "
3,000 - 4,000	" 20 "
4,000 - 5,000	" 25 "
5,000 - 6,000	" 30 "
6,000 - 7,000	" 35 "
7,000 - 8,000	" 40 "
8,000 - 9,000	" 45 "
9,000 -	" 50 "

$F = A + B + 1.5S + 2M$

where,

A : Acidity or alkalinity required to maintain pH value of sewage within the range from 5.0 to 9.0 (mg/lit).

B : Excess of BOD load in sewage over 600 mg/lit (mg/lit).

S : Excess of SS load in sewage over 600 mg/lit (mg/lit).

M : Excess of mineral oil content of sewage over 5 mg/lit and excess of animal and plant oil content of sewage over 30 mg/lit (mg/lit).

6) Law concerning Entrepreneur's Financial Sharing in the Cost of Environmental Pollution Control Works

This law was enacted in 1970 on the principle of the discharger's responsibility for pollution control. The special public sewage works are referred to in this law as the environmental pollution control works. Under the provisions of this law, that portion of the construction cost of specified public sewerage which is required for industrial waste water is charged to the discharging enterprises after deducting a certain fixed amount therefrom for equitable financial sharing on such enterprises and common households. Legal measures can be taken for compulsory collection of the burden sharing levied under this law.

7) Relationship between Industrial Waste Water and Sanitary Sewage

The Water Pollution Control Law was enacted for the purpose of controlling the quality of water which is discharged from factories and business establishments into public water bodies and is liable to cause pollution of public water bodies. Factories and business establishment discharging such heavily polluted water are called the specific business establishments. Control over water quality under this law is based on the uniform effluent standard supplied throughout the country as well as on the stricter control standards which are applied in specific areas subjected to heavy water pollution.

Public sewerage system or regional sewerage system embracing sewage treatment plants is excluded from the public water bodies. Since these sewerage systems cover specific business establishments within the scope of their service, industrial waste water discharged into public sewerage system and treated at the sewage treatment plant is subject to the water quality control under this law before it is discharged into public water bodies.

In order to keep the quality of water discharged from the treatment plant up to the effluent standard and thereby safeguard the water quality conservation function of sewerage system, the public sewerage system should exercise his control power to prevent the discharge of industrial waste water or other sewage whose toxic matter content is too high to be treated by or exceeds the capacity of the sewage treatment plant.

For this purpose, the Sewerage Law provides for the obligation of the discharger of heavily polluted waster water to send in the report notifying the commencement of waste water discharge in public sewerage system, to install facilities for pretreatment of waste water, and to measure the quality of discharged waste water. In particular, the pretreatment facilities installed at factories, etc. are demanded to be able to remove heavy metals, inorganic toxic matters and other matters which cannot be treated at the sewage treatment plants to the certain extent. As for the matters which can be treated at the sewage treatment plants, the pretreatment facilities are demanded to be able to remove that portion of their content which is beyond the capacity of the plant.

Example:

	Standard of Pretreatment	Uniform Effluent Quality Standard of Water for Discharge into Public Water Bodies
Cyanide content	1 mg/lit	1 mg/lit
BOD	600 mg/lit or more as determined by the controller of public sewerage system	120 mg/lit

Pretreatment described above is required in view of the capacity of the sewage treatment plant. With respect to such industrial waste water which meets the pretreatment standard and can therefore be treated at the sewage treatment plants, it is considered necessary to collect the sewer charges according to the quality of discharged water to maintain impartiality for factories and households discharging sewage directly in public water bodies. Standard for collecting charges by such quality difference is one of the major subject matters to be discussed at the third Committee for Reviewal of Sewerage Financing. When this standard is established, waste water dischargers will be required to make choice between two alternatives, i. e., in one case they will be required to carry out pretreatment to the prescribed standard and pay the quality-based sewage charges, and in the other they will be demanded to carry out pretreatment to the extent that the waste water can be directly discharged into public water bodies. In the latter case, the dischargers will not be required to pay the quality-based charges.

6. ESTABLISHMENT OF JAPAN SEWAGE WORKS CORPORATION

6-1 Background of Establishment of the New Organization

The Japan Sewage Works Corporation was established on November 1, 1972 under the relevant law to cope with the following situation.

1) Sewerage service is urgently needed to prevent water pollution.
2) The system for accelerated sewerage service is not firmly established.
3) Local municipalities need to be financially supported for smooth implementation of their sewerage works.
4) New sewage techniques should be developed and applied for practical purposes.

Japan's sewage works have in principle been undertaken on the responsibility of municipalities. However, since their implementation demands application of new techniques and huge capital input, sewerage service has so far been made in a limited number of large cities.

Number of cities undertaking sewage works totals 306 in 1972, but this should be increased to cover as many as some 2,900 municipalities if solution is to be brought for the problem of spreading water pollution.

At present, virtually no technical experts are found in the municipalities where sewage works are planned to be put in execution. It is imperative, therefore, to establish a pooling system of well-trained technicians who will be deputed to local governments to take charge of construction work and provide in-service training.

Sewerage construction work for preventing water pollution incurs heavy financial burden on the undertaking municipalities due to the huge initial capital input required for installation of sewage treatment plants. A new financing system should therefore be established under which part of the construction cost will be advanced to alleviate budgetary pressure on local governments.

Development of new techniques is also a pressing need of today. Application of new techniques is required particularly in the field of advanced sewage and sludge treatment. Tests and experiments as well as evaluation of sewage facilities should be enhanced by the joint efforts of private and government research institutes.

To meet all these social requirements, both the national government and local municipalities undertaking sewage works should unite their efforts in starting a new institutional improvement. The Japan Sewage Works Corporation Law was formulated for this purpose and enacted on November 1, 1972.

6-2 Duties and Activities of the Corporation

The followings are the outline of activities to be undertaken by the Corporation.

(1) Technical assistance

(2) Execution of construction work entrusted by municipalities.

(3) Training and education of technicians.

(4) Development and application of new technology.

6-3 Sponsorship to the Corporation

The corporation is a special juridical person established under a special law, the Japan Sewage Works Corporation Law, and its capital fund and administration cost are borne equally by the national government and local governments.

The capital fund is expected to be increased from 300 million yen (1 million dollars) in 1972 to a total 3,000 million yen (10 million dollars) by 1976, and will be appropriated for construction of permanent properties such as research institutes, training centers, trainees' dormitories, and facilities and equipment for research and training.

The administration cost comprises the wages of staffs, travelling expenses, cost of office supplies and other consumable articles, and rent of the Corporation building. Budgetary arrangements have already been made for earmarking 100 million yen (330 thousand dollars) for 1972.

The expenses required for technical assistance to local municipalities are determined and disbursed by the nature of aid according to an agreement concluded between the Corporation and aid-receiving local municipalities.

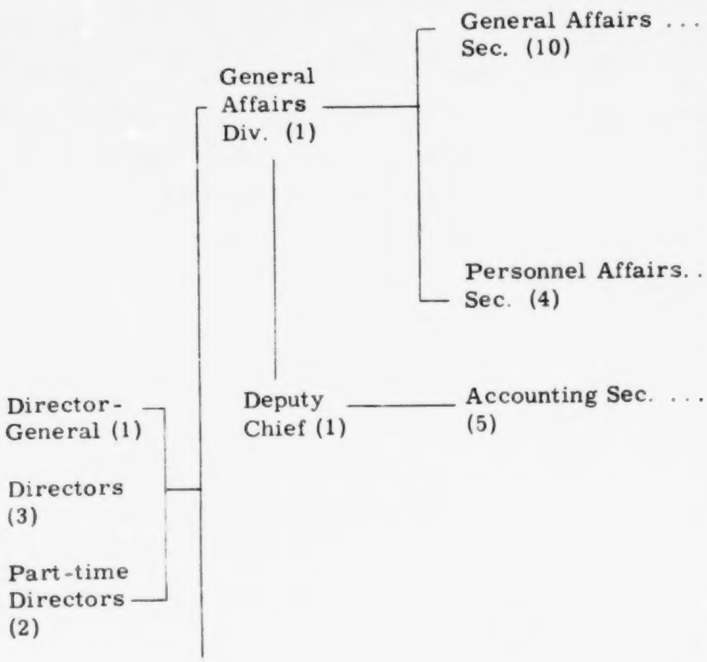
6-4 Organization and Structure of the Corporation

The Corporation is required to have the organizational setup best suited for performing the activities introduced in Section 6-2. The Corporation is still very small in scale since it made a start only in November 1972. In 1973, however, its technical cooperation department will be divided into two sections, one for East Japan and the other for West Japan, so that the aid activities will be carried out in an intensified and efficient manner.

The organizational setup of the Corporation in 1973 will be as illustrated below.

Organization and Number of Staff Members of the Japan Sewage Works Corporation

Auditor (1) .... Inspection of the Corporation's activities.

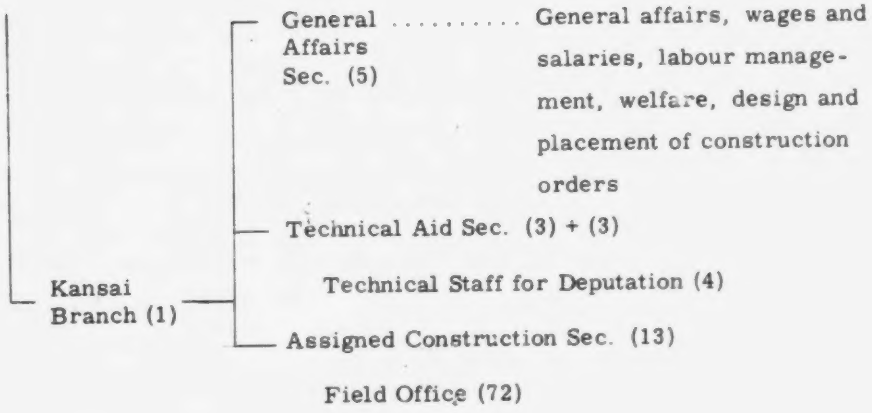


General Affairs Sec. (10) ... General affairs, arrangements for the meetings of board of directors, secrearial works, archives and documents, and internal regulations.

Personnel Affairs Sec. (4) .. Personnel affairs, wages and salaries, labour management, welfare (dormitories).

Accounting Sec. (5) ... Budgetary planning, settlement of accounts, receipt and disbursement of construction expenses, placement of orders for design and construction works, and fund application planning.

Planning Div. (1)	Planning Sec. (6)		Project planning, publicity activities, and arrangements for the meetings of councilors.
	Technical Control Sec. (4)		Investigation and inspection.
Technical Div. (1)	Technical Aid Sec. (4) + (4)		Provision of advice and guidance in the construction, management and maintenance of municipal sewerage systems.
		Technical Staff for Deputation (6)	Technical aid.
Deputy Chief (1)			
	Assigned Construction Sec. (13)		Entrusting of construction design to contractors, and issuance of instructions and guidance to consultants firms.
		Field Office (63)	Supervision of assigned construction work.
Training Div. (1)	Training Administration Sec. (4)		Recruiting of trainees and general affairs.
	Training Sec. (8)		Compilation of curriculum, lectures and field training.
Research Inst. (1)	1st Technical Development Sec. (5)		Analysis of water quality, and development and testing of measuring instrument.
	2nd Technical Development Sec. (5)		Development and testing of tertiary and sludge treatment facilities and toxic matter removal facilities.
	Systems Development Sec. (4)		Development and testing of automatic designing, operation and supervisory systems.


General Affairs Sec. (5)
General affairs, wages and salaries, labour management, welfare, design and placement of construction orders
Technical Aid Sec. (3) + (3)
Technical Staff for Deputation (4)
Kansai Branch (1)
Assigned Construction Sec. (13)
Field Office (72)

Since the Corporation's staff should carry out the design, management and maintenance of sewage facilities at the request of local public bodies, they will be composed chiefly of the officials deputed from the national government and local municipalities and hold the status of public service personnel.

7. AN EXAMPLE OF FIGHTING INDUSTRIAL WASTE POLLUTION IN YOKOHAMA

7-1 Introduction

The City of Yokohama, as is well known, embraces a heavy industrial complex including iron and steel mills, oil refineries and petro-chemical plants along its coastal line with Yokohama Harbor as the center, and with a light industrial district at its back.

Almost all of the inland area has been developed into housing and on the low land along main rivers, factory groups are increasing. Since flows are small for the rivers in the city and the domestic wastes are increasing due to the remarkable increase in population, not only organic pollution but also pollution by industrial waste water is progressing, and the damage to sewage treatment plants is steeply increasing, requiring countermeasures against industrial waste water pollution.

Such being, for the improvement of city environment, Yokohama has reclaimed a land on coast, as a pert of city planning, in order to move into this district the factories so far mixed in the city area causing environmental disruption. By so doing, not only the modernization of industry can be achieved but also by utilizing the land space left with the factories removed, re-development of streets and recovery of greens can be realized. As one step along such a program, the development of Torihama District has been put into operation.

The paper describes the countermeasures against the industrial effluent pollution for a collective of factories of minor enterprises located in this district. Presented below is a collective pre-treatment system for the District.

7-2 Brief Review of Countermeasures against Industrial Waste Water Pollution

Countermeasures hitherto taken against industrial waste water pollution are classified as follows.

1 To receive industrial waste water into public sewerage system only after eliminating specific substances at in-factory unit.

2 With the exception of special cases, to treat it in combination with municipal sewage at public sewerage system. (This is called "Combined treatment".)

3 To discharge it directly to public water bodies after being treated independently.

4 To receive it into public sewerage system after being pre-treated collectively. (This is called "Collective pre-treatment".)

The method 1 has hitherto been adopted generally. According to the Sewerage Law, all the industrial waste water in the drainage area must, as a rule, be taken into public sewerage system. However, in order to maintain the city facility properly, in-factory units or facilities should be installed to eliminate any toxic and damaging substances which may damage sewers or impede the sewage treatment operation. Especially, since public sewage works are controlled subject to the discharge standards stipulated by the Water Pollution Control Law or those of more severe nature set forth by the prefectural regulations, it has become necessary to strengthen the supervision and guidance for such in-factory pre-treatment facilities.

In view of the past results, independent units eliminating specific substances are not always appropriate and there remain big problems in the future in counting on the real effects in monitering the water quality and supervising the factories.

For the method 2 , unless toxic and damaging substances are prevented from entering, a sewage treatment plant would be jeopardized or its treatment efficiency degraded.

Mostly industrial waste water fluctuates to a large extent in quality and quantity and difficulties are involved in the treatment. In order to maintain the effluent quality to the standards of sewage treatment plants, at least not only such combustible and explosive substances such as gasoline, and strong acid wastes of less than 3. 0 in pH, which may damage the facility, but also such waste water involving heavy metals which are difficult to treat, should be treated at the pollution source.

The method 3 is considered to be limited to the following cases:

a) Where public sewerage system has not been prepared yet and the waste water has to be discharged directly to river or coastal waters, but the untreated discharge may affect a drinking water source or fisheries.

b) A large-scale factory along the coast which is not included in the treatment district of a public sewerage system and which should treat its waste water independently.

Besides the above, in treating concentrated waste water such as pickling-plating waste water, there are some cases in which treatment should eliminate specific substances so as to be acceptable to flow into the public sewerage system, but also to treat so as to be dischargeable independently to public water bodies utilizing high treatment efficiency and by-product recovery.

The method 4 is to pre-treat the sewage, most of which consists of industrial waste water, to a certain extent before accommodating it at sewage treatment plants.

With this method, except for an extremely bad quality waste water, generally a factory can discharge to a public sewerage system without any facilities to eliminate specific substances. This method is considered effective where it is practically difficult to make a factory install an independent facilities as above 1 However, combined treatment of various types of industrial waste water involves technological difficulties and in most cases, construction and operating costs are uneconomical. The present water pollution problems lie not only in the simple reduction of pollution by so-called environment items such as BOD and SS, but in the prohibition of flowing out into public water bodies of cyanides, heavy metals, etc. caused by industrial waste water. Furthermore, considering that a sewage treatment plant is not able to remove such substances adequately, combined treatment itself, though hitherto considered economical, should be reconsidered.

7-3 Outline of Torihama District Reclaimed Land

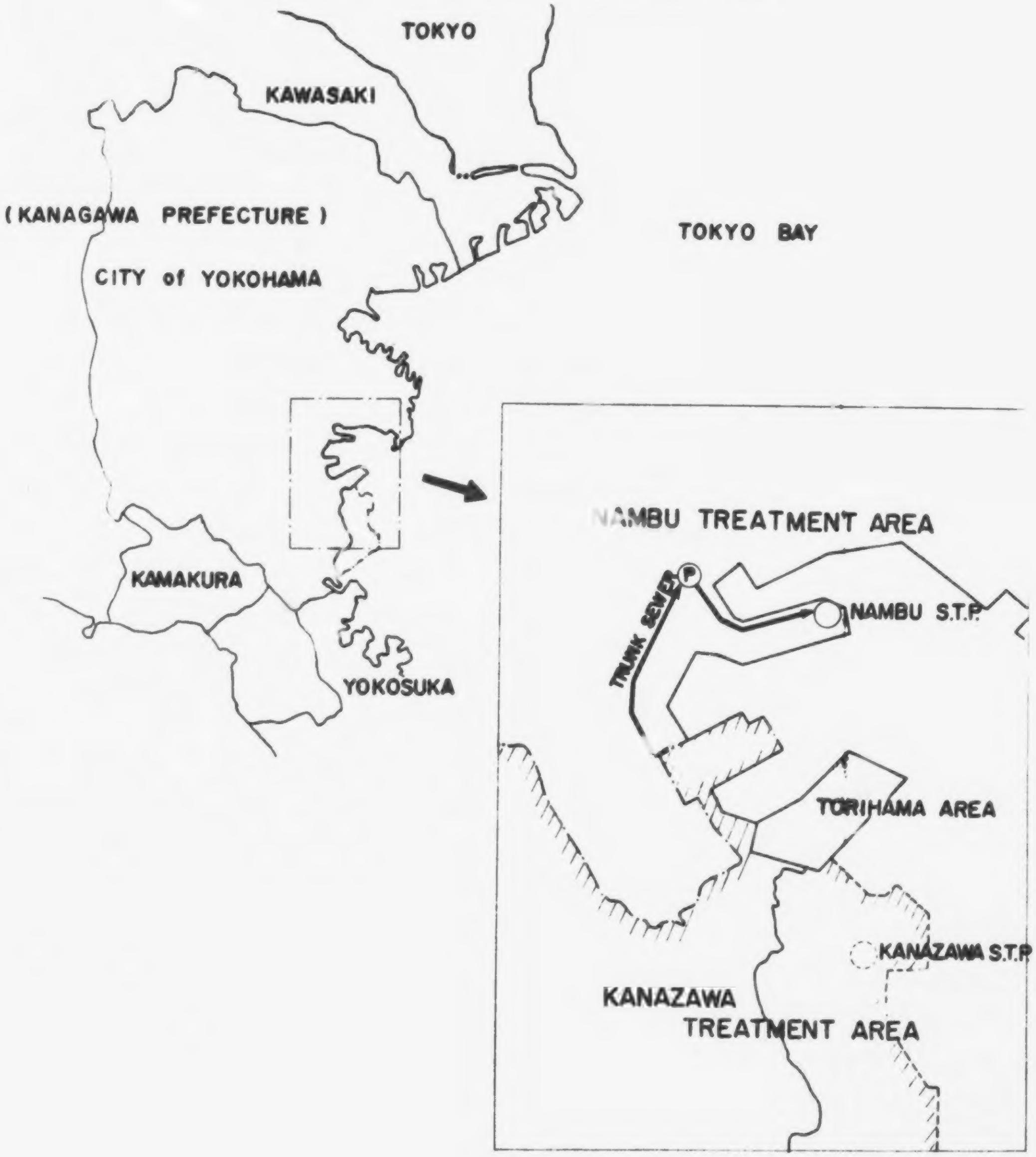
This reclaimed land, completed in January 1972, having an area of 144.6 ha is the site for coastal collective factories for minor enterprises. The number of establishments entering this district is 169 in total, among which, 21 are cooperative unions each composing numerous minor enterprises. Therefore, the actual number of factories is assumed to exceed 300. The types of industry are: fabricated metal products manufacturing, machinery manufacturing, chemical industry, construction, transport equipment manufacturing, transport, textiles, food stuffs processing, etc. 90% of them are occupied by minor enterprises each having less than 100 employees. By this, you can imagine the characteristics of this coastal industrial area. Since such small scale enterprises are the main constituents of the district, countermeasures against industrial waste water pollution become very difficult and vital.

7-4 Discharge Regulation and Sewerage System Planning

Effluent standards applied for new factories along the coast are stipulated by prefectural regulations, as: 25 mg/1 COD and 70 mg/1 SS. Therefore, assuming that a factory conducts its treatment independently, extreme difficulties would be involved.

Meanwhile, the planned public sewerage system for this reclaimed land belongs to the Kanazawa Treatment District, as shown in Fig. 7-1. Waste water from factories entering this district is to be taken into public sewerage system after specific substances are eliminated, and to be treated at the Kanazawa Sewage Treatment Plant. However, no sewerage system including a treatment plant has been prepared yet and there exists no normal means of utilizing a public sewerage system. However, the South Treatment District just neighboring this district has made considerable progress in the preparation of a sewerage system including the treatment plant, and the trunk sewer has been laid up to a point about 3 km distant from the site. Therefore, it is considered economical to pump the district's effluent to this point and utilize provisionally the spare capacity of the South Sewage Treatment Plant.

FIG 7-1. Location of Torihama Area



7-5 Grasping the Quality and Quantity of Industrial Waste Water

In planning the treatment of wastes, it is necessary to grasp the waste water quality and quantity for the basis. However, for a new industrial area starting operations in the future, it is impossible to obtain data by actual measurement and data have to be forecast by survey through correspondence and interviews with respective enterprises. Until assembling the final data and convincing the enterprises, repeated changes and corrections were needed, the main reasons for which are enumerated below.

1 As for using the water supply quantity as the basis of waste water quantity, apparent quantity figures having no definite basis were reported.

2 There were many cases of making excess estimates for domestic waste water per employee per day.

3 At the stage of offering rough estimates for charges, some enterprises proposed to change the quality and quantity of their waste water by modifying their processes, in order to reduce their charges.

4 Only a few enterprises submitted analytical data of waste water of their existing factories and final recognition has only been reached through several discussions with the enterprises.

The survey results are summarized in Tables 7-1, 7-2 and 7-3.

Table 7-1 Scale of Enterprises by Waste Flow Rate

Total Flow Rate / Classification	Number						Total
	~10m^3/ day	11~20m^3/ day	21 ~ 50m^3/ day	51~100m^3/ day	101 ~ 200m^3/ day	201m^3/day ~	
Fabrication metal products	29	8	2	—	1		40
Machinary	17	4	3	—	—	1 (501m^3/day)	25
Chemicals	3	2	3	2	—	—	10
Construction	17	1	—	—	—	—	18
Transport quipment	5	3	1	—	—	—	9
Transport	14	3	3	—	—	—	20
Textiles	4	2	1	—	—	—	7
Foodstuffs	4	9	6	1	1	—	21
Other	2	1	3	7	3	1 (750m^3/day)	17
Public Center Market	—	—	—	—	—	2 (3500m^3/day)	2
Total	(56%) 95	(20%) 33	(13%) 22	(6%) 10	(3%) 5	(2%) 4	(100%) 169

Table 7-2 Supposed Wastes Quality by Industrial Classification

Parameter Classification	BOD (mg/ℓ)	SS (mg/ℓ)	Oil and Grease (mg/ℓ)
Fabricated metal products	40	200	100
Machinary	40 ~ 100	200 ~ 300	50 ~ 100
Chemicals	200	200	100
Construction	40	500	50
Transport equipment	50	100	150
Transport	100	200	200
Texitiles	400 ~ 800	200 ~ 500	200 ~ 500
Foodstuffs	100 ~ 8,000	50 ~ 4,000	50 ~ 2,000
Other	20 ~ 300	50 ~ 200	50 ~ 500
Public Central Market	700	500	100

Table 7-3 Flow Rate and Concentration of Plaiting Wastes

Classification / Name of Enterprise	Cyanide waste		Metal waste	
A (Rust Removing)	PPm	m^3	PPm 120 (-)	m^3/ 14
B (Plating)	30	53. 7	175 (30)	203. 3
C (Plating)	50	6. 3	140 (50)	23. 7
D (Film Developing)	—	—	70 (-)	60. 1
E (Rust Removing)	—	—	350 (15)	15
F (Printing)	—	—	80 (-)	24
Total	—	60. 0	—	340. 1

( ): Cromium waste.

Combined treatment of all of these waste water collected would be not only uneconomical since the reduction efficiency of toxic substances would be lowered, but also would be sometimes hazardous when materials such as cyanides are involved. Therefore, the waste water should be separated into pickling-plating waste water, general process waste water and miscellaneous waste water, and further the pickling-plating waste water should be separated into acid-alkali wastes, heavy metal wastes and cyanide wastes. However, for the convenience of piping, the city has decided to classify the treatment lines (piping and treatment facilities) into at least 4 types, as follows.

Miscellaneous waste water: Domestic wastes such as kitchen wastes and night soil, and process wastes not containing oil, metals, etc. which are immediately treatable by biological treatment.

General process waste water: Wastes from work processes not involving toxic substances but highly-concentrated organic matters, oil and fat, etc. which affect the municipal sewage treatment, therefore needing a separate process to eliminate specific substances.

Metal waste water: Wastes from pickling-plating processes involving heavy metals and toxic substances (except cyanides) and those from metal finishing operations needing a separate process to eliminate specific substances.

Cyanide waste water: Wastes from acid-plating processes needing a separate process to eliminate cyanides.

Table-7. 4 shows a summary of waste water quantities classified by the above 4 types of treatment lines.

Table 7-4 Flow Rate by Type of Wastes

(m³/day)

Classification	Domestic Waste	Ordinary Process Waste	Plating Waste		Total
			Cyanide	Metal	
Fabricated metal products	320. 9	149. 0	-	14. 0	483. 9
Machinary	433. 0	63. 0	60. 0	227. 0	783. 0
Chemicals	235. 5	53. 0	-	75. 1	363. 6
Construction	85. 0	8. 0	-	-	93. 0
Transport equipment	120. 0	19. 0	-	-	139. 0
Transport	85. 5	97. 0	-	-	182. 5
Textiles	56. 0	32. 5	-	-	88. 5
Foodstuffs	324. 4	258. 6	-	-	583. 0
Other	952. 4	960. 6	-	24. 0	1, 936. 9
Public Center Market	1, 720. 0	1, 780. 0	-	-	3, 500. 0
Total	4, 332. 7	3, 420. 6	60. 0	340. 1	8, 153. 4

7-6 Countermeasures against Industrial Waste Water at Torihama District

7-6-1 Basic plan

1 The industrial waste water from this district is allowed to flow into the public sewerage system of the South Treatment District for the time being. After the necessary pre-treatment as required and after being treated biologically together with municipal sewage at the South Treatment Plant, it is discharged to Negishi Bay. In the future, the pretreated waste water will be discharged into the public sewerage system of the Kanazawa Treatment District and to the Kanazawa Treatment Plant.

2 Among the industrial waste water, metal waste water, cyanide waste water and general process waste water are separated from the miscellaneous waste water for which pre-treatment is not required, and are treated at the collective pre-treatment facilities to the quality equal to general municipal sewage.

3 Facilities for collective pre-treatment of industrial waste water will be constructed by the city at the expense of enterprises. The collective pre-treatment facilities (including piping) will be operated by the city similarlies at the enterprises' expense, and the title for assets will belong to the city.

Comments on 1

The survey of the quality and quantity of industrial waste water produced in this district revealed that a large quantity of bad quality wastes from pickling-plating and general process waste water needing pre-treatment are involved. After studying how to treat them, the city has decided to conduct collective pre-treatment and treat the pretreated waste water ultimately with in the public sewerage system, for the following reasons:

a) Participating factories are mostly minor enterprises, therefore, at the present, in view of their technology and menagement ability for waste water treatment, proper operation can be hardly expected in having them treat their waste water independently. Meanwhile, if collective treatment is adopted and is operated by city, who has competent sewage engineers, proper operation can be expected.

b) Public sewerage system has not been prepared yet in this district. If individual treatment is adopted, the more severe discharge requirements applying to coastal water bodies as stipulated by the prefecture should be used. Compared to collective pre-treatment plus discharge to public sewerage system, the former scheme would be extremely costly in both construction and operation.

c) Among the establishments to be located in this district, a municipal wholesale market is included. Its waste water occupies a great share of the total in both quality and quantity, and the waste water treatment is the city's responsibility.

Comments on 2

With the treatment of combined waste water of various types, the removal ratios decrease and not only would the treatment costs become uneconomical but also a large quantity of sludge containing heavy metals would be produced, causing the problems of ultimate disposal. Therefore, separate treatment is adopted.

Comments on 3

Pollution control of public water bodies is the responsibility of the municipal government, who therefore should take effective measures against pollution sources. Meanwhile, industrial waste water pollution sources should be treated as the enterprises' responsibility.

Accordingly, it has been judged proper in view of the present situation that the city should take the responsibility for construction and operation of the treatment facilities at the expense of the enterprises who would cause the pollution.

7-6-2 Collection and treatment system for industrial waste water

1 For collection of waste water, a separate system is adopted and in addition to the existing storm sewers, separate sewers for industrial waste water will be laid.

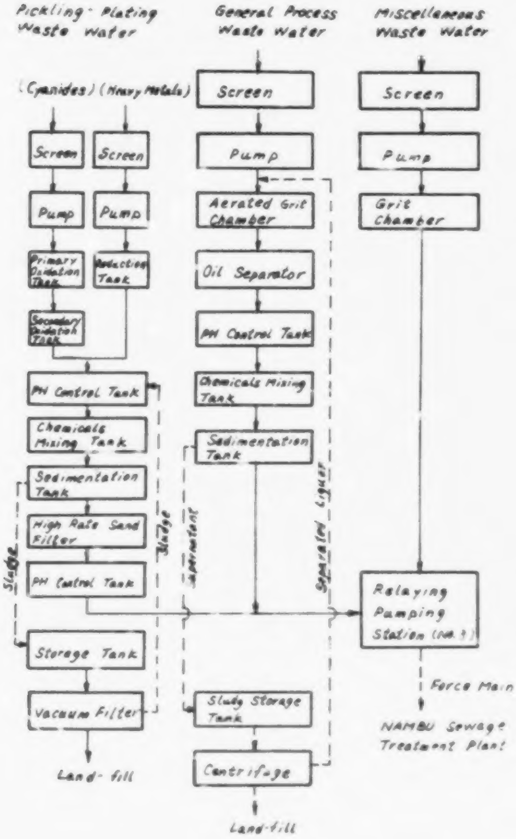
2 The industrial waste water sewers will be divided into 4 lines: miscellaneous waste water, general process waste water, cyanide waste water and heavy metal waste water lines. The miscellaneous waste water line needs no pre-treatment, while the other 3 lines need pre-treatment.

3 Cyanide and heavy metal waste water will be led into and treated at a pickling-plating waste water treatment facilities and will then be combined with the miscellaneous waste water. General process waste water will be led into and treated at the general process waste water treatment facilities, and the pre-treated effluent will be pumped to the South Sewage Treatment Plant, together with all the other effluent combined.

7-6-3 Treatment processes for industrial waste water

Treatment processes for industrial waste water by types of waste water are as shown in Figs. 7-2, 7-3 and 7-4.

Fig. 7-2 Flow Sheet of Collective Pre-treatment Plant for Industrial Waste Water



As for sludge treatment, in view of land space economy, odor control and high dewatering efficiency, the sludge will be dewatered mechanically and ultimately disposed of as land-fill.

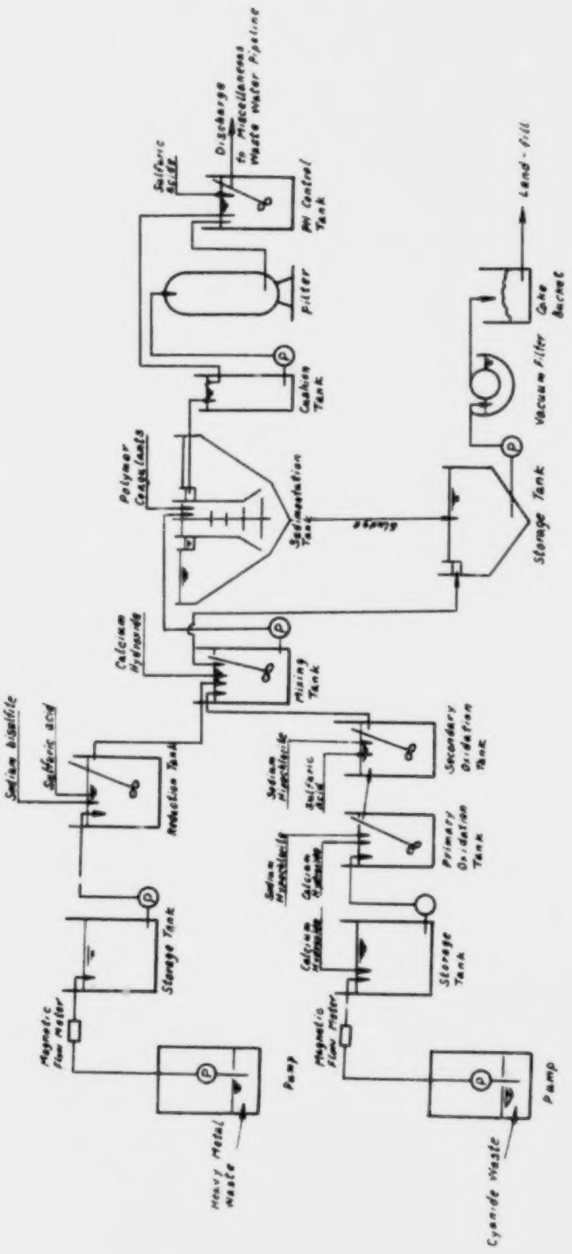
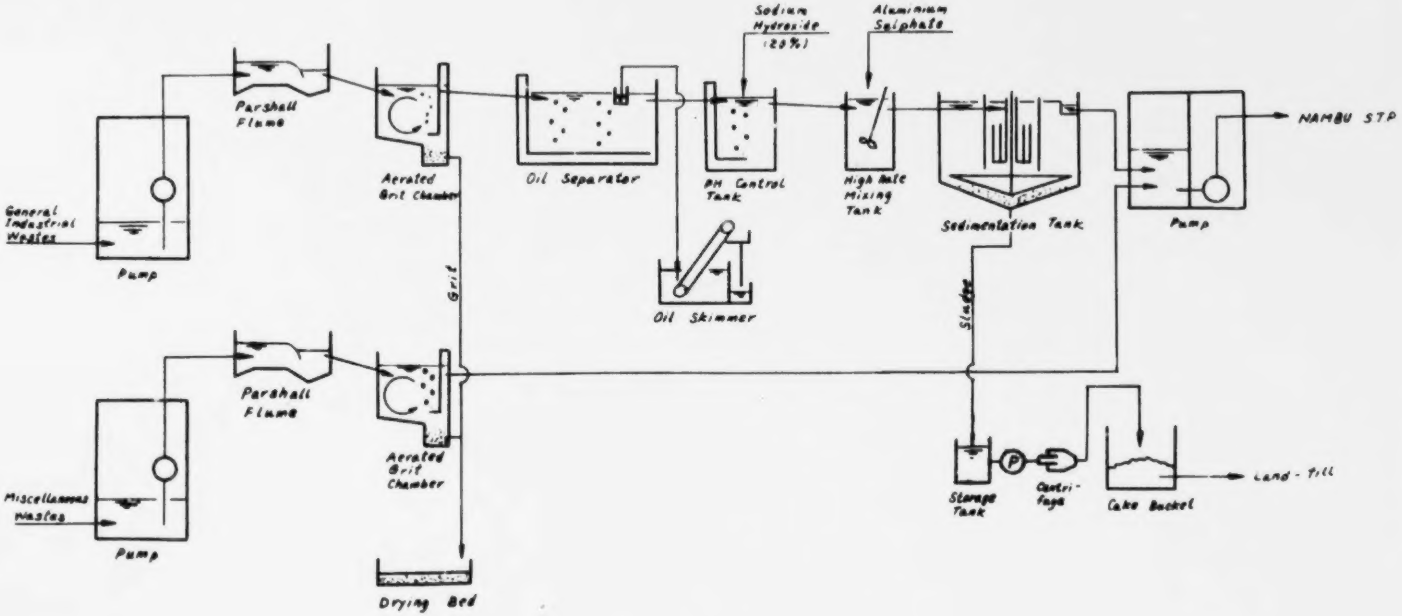


Fig. 7-3 Flow Sheet of Pre-treatment Facilities for Pickling-Plating Waste Water

Fig. 7-4 Flow Sheet of Pre-treatment Facilities General Process Waste Water



7-6-4 Charges and finance

(1) How to impose charges

In principle, for imposing charges, all the costs incurred by the collective pre-treatment of industrial waste water will be borne by the enterprises concerned and the calculation formula for charging the construction costs for the respective types of waste water are set as follows.

a) Charges for miscellaneous waste water

Costs for piping, relaying pumping station and land space for the miscellaneous waste water line are prorated in proportion to the respective quantity discharged.

b) Charges for general process waste water

Costs for piping, relaying pumping station and land space for the general process waste water line are prorated in proportion to the respective quantity discharged, while costs for the treatment facilities are prorated in proportion to quality (BOD, SS, oil and fat) and quantity discharged.

c) Charges for pickling-plating waste water

Costs for the pickling-plating waste water pre-treatment line are charged both on a uniform charge basis and the proration according to quality and quantity discharged. The costs remaining after uniform charges are subtracted are fivided into two parts; for cyanides and for other pickling-plating waste water. For both parts, costs for piping and land space are prorated in proportion to quantity discharged, while the costs for the pre-treatment facilities are prorated in proportion to both quality (cyanides, chromium and other heavy metals, organic matters, etc.) and quantity discharged. After negotiations with enterprises, the amount of uniform charges have been decided at 30% of total costs ultimately.

(2) Financing for the enterprises

For the minor enterprises (155 firms), the city's finance system for pollution control facilities for minor enterprises will be applied.

b) For the big enterprises (10 firms), no financing is planned but 2-year installment payments will be allowed.

7-6-5 Project cost and funding

Project cost and funding for the industrial waste water pre-treatment for this district are shown in Table 7-5.

Table 7-5 Budget and Finances Type of Wastes

(Thousand Yen)

Items	Type of Wastes			Total	Finances	Remarks
	Domestic	Plating	Ordinary Process			
Pipe	229,500	35,200	146,800	411,500	Charges to Enterprises	Total Length 11,930m
Pumping Station (No. 1)	10,340		6,670	17,010		2
Pumping Station (No. 2)	38,433	2,113	19,004	59,550		1
Treatment Plants		60,000	242,500	302,500		2
Land for Plants	1,812	8,500	33,888	44,200		$4,390m^2$
Total	280,085	105,813	448,862	834,760		
Pressure Pipe				74,000	Charge to City	300m x 2

7-7 Operation of Facilities

It has been decided that this collective pre-treatment facilities should be operated by the city and the assets after construction would belong to the city. However, to ensure the proper operation, the following points have been considered in the relations with the enterprises who discharge industrial waste water:

1 In allocating user charges for operating the collective pre-treatment facilities, the actual expense compensation system is adopted, trying to be fair in allocating charges in proportion to the quality and quantity of waste water discharged. In addition to the charges above, the user charges for public sewerage system are imposed.

2 To ascertain the quality and quantity of industrial waste water discharged, spot inspections and adequate monitering are conducted, whenever necessary.

3 For the quantity of miscellaneous waste water, general process waste water and pickling-plating waste water to be discharged, maximum limits are set forth. Since there is no plan to extend this facilities in the future, it is necessary to restrict the quantity discharged for proper operation.

4 The discharge of any substances impeding proper operation is forbidden. Forbidden substances include: such substances as gasoline etc. causing fire, sand and grit leading to plugged piping, hot water at more than 50°C, the heat-resisting limit for PVC piping, and toxic substances such as mercury, cadmium, etc., which are not included in the reports from the enterprises.

5 For violation of the agreement on the quality and quantity of waste water, severe surcharge and penalty could be imposed, and restriction and prohibition of discharging waste water could be taken.

6 The right of utilization of the collective pre-treatment facilities could be transferred unless troubles in operation would be caused. Though the capacity of pre-treatment facilities is limited, as far as the operation is conducted within the limit, there is no influence to the treating capacity, even if the user changes. To this effect, the city is giving consideration to flexible management of the enterprises.

7-8 Conclusions

In fighting industrial waste water pollution, practice is more difficult than theory. In this concrete example in Yokohama, we have presented the countermeasures taken against industrial waste water from a minor enterprises complex on coastal reclaimed land. We believe this case will indicate a direction for fighting industrial waste water pollution in the future.

8. SLUDGE TREATMENT AND DISPOSAL IN TOKYO

8-1 Present Situation and Problems in Sludge Disposal

8-1-1 Volume of sludge

In 1978 when the project is sheduled to be completed, 9,500,000 residents living in the area of 53,458 hectars are expected to enjoy the sewarage. At that moment, the volume of sewage to be treated every day is estimated at 5,310,000 cubic meters and that of raw sludge produced every day at 63,720 cubic meters (water content: 98.5 percent). The sludge handling of Tokyo are indeed a battle against the vast volume.

In 1971, seven sewage treatment plants are under operation, where 3,130,000m^3 of sewage are processed and whereinto 37,560m^3 of raw sludge are produced per day. Table 8-1 shows the volumes of sewage and sludge in every plant.

8-1-2 Dewatering of Raw Sludge

All the sewage of Morigasaki Sewage Treatment Plant are forwarded under pressure by pumping to Shibaura Sewage treatment Plant because the daily output in former is not high, those of Ochiai Sewage Treatment Plant are sent in the same manner to Odai Sewage treatment Plant because the former plant is located in a residential district and also because it has no enough land, and those of Mikawashima Sewage Treatment Plant are pumped to Sunamachi Sewage Treatment Plant by the same reason as mentioned above. The distance of the sludge line between two each of these plants is all more or less 10 kilometer. In a summer season, sludge is septic during the travel through the pipe line. Therefor the processing plant often find it very difficult to concentrate the solid content by a gravity thickener.

The mixture (moisture content: 98,5 percent) of the primary sludge and the excess activated sludge is concentrated by gravity up to 96 percent, and then is left in a sludge digestion tank for 20 days at 35°C, and is finally dewatered thereafter by a vacuum filtration. Gravity thickened raw sewage, though not digested, can be dewatered with the vacuumfilter, if it is coagulated with lime by 15 percent and ferric chloride by 5 percent. This method will be employed in future.

Table 8-2 also shows the sludge treating and disposing methods in each plant. As seen in the table, each treatment plant has vacuum filters.

Belt filters are equiped in the newset Ukima Sewage Treatment Plant. They were adopted in this Plant in view of the finding that when Oliver filter is applied to dewater excess sludge produced from the activated sludge process treating heavy industrial waste water, filter madia is subject to clogging and life of the media is short.

The vacuum filtration tends to be less used although they have been extensively employed heretofore. In future, use of centrifuge is contemplated as the replacements. Although the quality of filtrate by a centrifuge may not be as good as that by a vacuum filter, the former has the advantages i) that its mechanical reliability is established, ii) that it requires far less installation area than a vacuum filter does though the former has the same functions as the latter, and iii) that it can be continuously operated without operator.

Table 8-1 Statistics of Sludge in Tokyo

Name of Drainage Area		Total Planning	At the end of 1971 Fiscal Year
Shibaura	1 Drainage Area ha (Rate of % Popularization)	6,420	6,156 (95.9)
	2 Amount of Influent m^3/d (Muximum of the Daity flow)	1,030,000	990,000
	3 Raw Sludge m^3/d	12,360	11,880
Mikawashima	1 Drainage Area ha	3,936	3,936 (100.0)
	2 Amount of Influent m^3/d	520,000	520,000
	3 Raw Sludge m^3/d	6,240	6,240
Sunamachi	1 Drainage Area ha	4,309	3,985 (92.4)
	2 Amount of Influent m^3/d	680,000	630,000
	3 Raw Sludge m^3/d	8,160	7,560
Odai	1 Drainage Area ha	3,519	2,886 (82.0)
	2 Amount of Influent m^3/d	420,000	340,000
	3 Raw Sludge m^3/d	5,040	4,080
Ochiai	1 Drainage Area ha	6,151	4,634 (75.3)
	2 Amount of Influent m^3/d	450,000	340,000
	3 Raw Sludge m^3/d	5,400	4,080
Morigasaki	1 Drainage Area ha	12,551	3,159 (25.2)
	2 Amount of Influent m^3/d	1,160,000	290,000
	3 Raw Sludge m^3/d	13,920	3,480
Kosuge	1 Drainage Area ha	5,382	–
	2 Amount of Influent m^3/d	290,000	–
	3 Raw Sludge m^3/d	3,480	–
Kasai	1 Drainage Area ha	5,193	–
	2 Amount of Influent m^3/d	240,000	–
	3 Raw Sludge m^3/d	2,880	–
Shingashi	1 Drainage Area ha	5,997	332 (5.5)
	2 Amount of Influent m^3/d	520,000	20,000
	3 Raw Sludge m^3/d	6,240	240
Total	1 Drainage Area ha	53,458	25,088 (46.9)
	2 Amount of Influent m^3/d	5,310,000	3,130,000
	3 Raw Sludge m^3/d	63,720	37,560

Table 8-2 Current Sludge Handling Process

(1) Shibaura

Gravity Thickening → Anaerobic Digestion → Vacuum Filtration → Land Reclamation in Tokyo Bay

(2) Mikawashima

Gravity Thickening →
Pumped 13 kilo meters to Sunamachi Plant

(3) Sunamachi

Gravity Thickening → Vacuum Filtration → Incineration → Dumping in Tokyo Bay

(4) Odai

Gravity Thickening → Vacuum Filtration → Incineration → Landfill

(5) Morigasaki

Pumping 8.6 kilo meters to Shibaura Plant

(6) Ochiai

Gravity Thickening → Pumping 10 kilo meters to Odai Plant

(7) Shingashi

Gravity Thickening → Vacuum Filtration → Incineration → Sanitary Landfill

8-1-3 Incineration of dewatered Cakes

In the three sewage treatment plants of Odai, Sunamachi and Ukima, dewatered cakes are burnt to ashes in multiple hearth incinerators. Single-stage scrubbers may be quite enough for almost always, but three-stage scrubbers are used to prevent the exhausted gas from polluting the environments for triple security. In newly built sewage treatment plants, a sand fluid bed incinalator will be installed.

8-1-4 Final Disposal

Dewatered cakes produced at Shibaura Sewage Treatment Plant are discharged into sheet-piled enclosures in that part of Tokyo Bay projected for reclamation land.

Ashes turned out of the incinerators of Sunamachi Sewage Treatment Plant are also applied for land reclamation.

Ukima sewage treatment Plant and Odai sewage treatment Plant that are located inland use their ashes produced by incineration for sanitary landfilling. In either case of land reclamation or sanitary landfilling, incineration will precede in future. For the purpose of landfil or land reclamation, no sludge cake will be applied.

8-1-5 Contamination by Heavy Metals

Concentration of taxicants measured at the inlets and the outlets of the sewage treatment plants are shown in Table 8-3 the difference between the concentration at the inlet and the outlet of the plant is due to what was taken out of the plant with sludge.

From the table above, remarkably high concentrations of the toxicants are noticed in the inflow to Ukima sewage treatment Plant where industrial waste constitutes a large portion of the inflow. Table 8-4 shows the analytical results of the concentrations of the toxic matter contained in the sludge cakes of the several sewage treatment plants. The concentrations of the toxic matter in the sludge cakes of Ukima Plant are seen by far higher than those of other plants since those toxic components equivalent to the difference between the concentrations at the inlet and those at the outlet are transferred to the sludge cakes.

Burning of sludge cakes may scatter toxic materials into the air, and dumping in the bay for land reclamation may disperse them into the sea. Table 8-5 shows the analytical results of the quality of the sea-water surrounding the reclamation land in Tokyo Bay. All results indicate negative levels. Breakdown of cleaned exhaust gas from incinerators is shown in Table 8-6 which indicates that the concentrations of sulfur oxides, smoke dust, cadmium and its compounds, and lead and its compounds which are the principal factors for the contamination of the air, are all within the regulating standards.

Thus, the toxic matter including heavy metals originated in sewage is not contaminating the environments so far. But they cannot be removed through a standard biological treatment process. For this reason, the Sewerage Las was amended to eliminate toxic matter at very biginning. That is, the law inhibits discharge of toxic heavy metals into public sewerages. It is duly expected therefore that the concentrations of heavy metals in sewage will be greatly reduced when the law is carried into effect.

Table 8-3 Concentration of Toxicant Substances in Influent and Effluent at Seven Sewage Treatment Plants in Tokyo

Name of Treatment Plant / Toxicant Substance	Shibaura		Morigasaki		Mikawashima		Odai		Shingashi		Sunamachi		Ochiai		Allowable Muximum Concentration
Sumpling Point	Influent	Effluent	I	E	I	E	I	E	I	E	I	E	I	E	
Cyanide	0.1	T	0.1	T	0.2	0	T	T	0.1	0.1	0.1	T	T	T	1
Total Chromium	0.3	0.2	1.0	T	0.1	T	0.3	T	2.5	1.0	0.7	0.2	T	0	2
Hexavalent Chromium	0	0	0	0	0	0	0	0	0.16	0	0.01	0	0	0	0.5
Cadomium	0.01	0	0.01	T	0	0	0	0.01	0.04	0.02	0	0	0	0	0.1
Arsenic	0	0	0	0	0	0	0	0	0.04	0.01	0.01	0	0	0	0.5
Plumbum	0.2	0	0.1	T	0	0	0	0	3.9	0.9	0.1	0.1	T	0	1
Organic Phosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total Mercury	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	Not detected
Alkyl Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Not detected

Unit: 1 Unit; ppm
2 T; Trace

Table 8-4 Concentration of Toxicant Substances in Dewatered Sludge Cake at Five Plants in Tokyo

Toxicant Substance / Name of Treatment Plant	Cyanide	Total Chromum	Cadmium	Plumbum	Arsenic	Total Mercury
Shibaura	0	310	20	190	0	4.8
Morigasaki	T	560	10	180	0	20.0
Sunamachi	0	580	10	130	12	3.4
Odai	3.0	530	30	260	0	4.0
Ukima	4.4	1,080	20	3,200	11	27.5

Notes: 1. Unit, mg/kg
2. T: Trace

Table 8-5 Toxicant Substances in Sea Water in and Around Land Reclamation Site in Tokyo Bay

Unit: ppm

Sampling Point * / Toxicant Substance	No. 1		No.2		No. 3		No. 4	
	Surface of the Sea	Bottom of the Sea	Surface of the Sea	Bottom of the Sea	Surface of the Sea	Bottom of the Sea	Surface of the Sea	Bottom of the Sea
Total Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alkyl Mercury	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hexavalent Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plumbum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Organic Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyanide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notes	The Inside				The Outside			

* of Fig. 8-1.

Fig. 8-1 Sampling Point

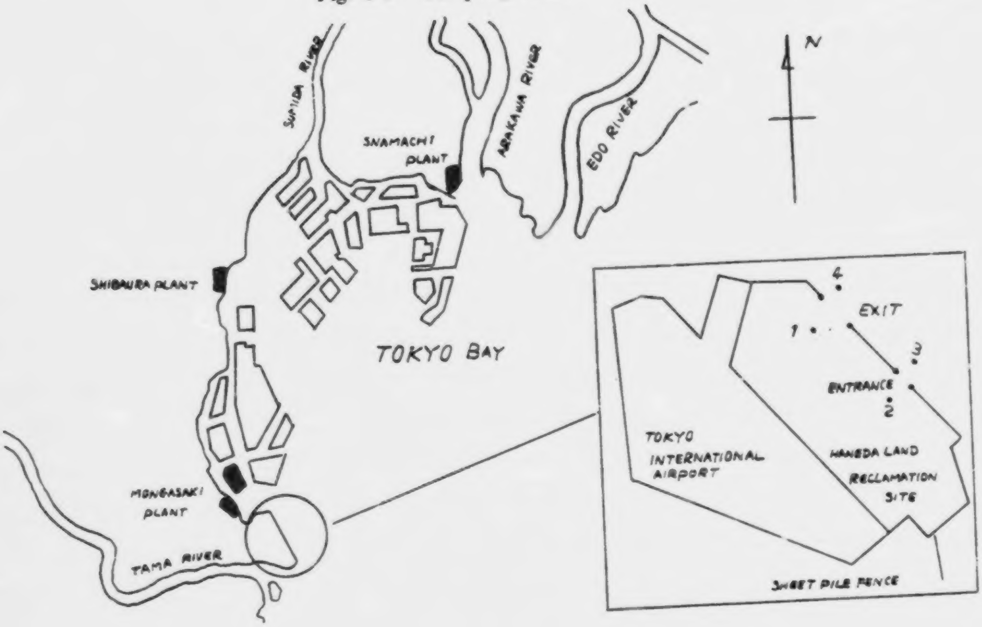


Table 8-6 Performance of "Three Stage Scrabbler"

Division / Items		Air Pollution Control Act		Odai Plant	Ukima Plant
				Height of Chimney 30 meter high One Stage Scrabbler	Height of Chimney 40 meter high Three Stage Scrabbler
Sulfer Oxides	Height of Chimney	30 m	5.69	1.30	–
		40 m	14.55	–	1.96
Soot		200		115.4	85
Cadmium and its Compound		1.0		0.29	0.02
Plumbum and its Compound		10, 20, 30		3.79	2.51

Notes:
1. Allowable maximum concentration of Sulfer Oxides in fume is determined on basis of height of the chimney.
2. Unit

Sulfer Oxides	Nm^3/Hour
Others	mg/Nm^3

8-2 Ocean Dumping of Municipal Sludge

8-2-1 Introduction

The concentration of population, progress of industry, construction of tall buildings, and water consumption per head in Tokyo have been increasing at a rate much greater than expected at first. Sewage to be treated has been sharply increasing. Nowadays, there is no room available for expanding sewage treatment facilities to cover the growing increment. To improve the existing facilities, therefor, we have deepened aeration tanks up to 30 feet and remodeled both the old 1st and the 2nd settling tanks to two-story tanks. Nevertheless, there is no space available to provide an additional sludge treatment equipment in the same sewage plant. Ever since ten and odd years ago, sludge of industrial large cities in Europe and the United States have been thrown away into the ocean, while we have been making it a rule to dispose sludge within the confines of the land of our own country. But now we cannot but think of the Pacific Ocean as the final distination of our sludge owing to the absolute reason of the lack of land. We are now studying the possibility and conceivable economical and technical problems of a new disposing process; all sludge from the several sewage treatment plants in Tokyo is pumped through a pipe line to a base built an reclaimed land in Tokyo Bay, it is gravity thickened, is then barged to the Pacific Ocean 200km away from Tokyo Bay, and then dumped there.

8-2-2 Purpose

As the field to accept vast quantity of sludge safely and constantly, the ocean has been used by many European and American industrial cities. In Japan confined by the surrounding sea to a narrow country where natural resources are not rich, the sea has been an important source of foodstuff including fishes and shellfishes from old times. Nowadays, there are also many industries depending on the sea and many recreation facilities attached to the seashore. In view of these facts, the dumping of sludge to the ocean must be carried out not only with cautions not to destroy the natural environments of the ocean but rather also with a purpose to promote the growth of the marine resources.

For realization of the sewage disposal into the ocean, research and investigation must be fully and carefully made in advance. The purposes of the research and investigation are as follows.

(1) To establish the possibility of disposal in the ocean.

(2) To establish an economical and rational method.

(3) To produce scientific research and investigation data in order to secure the understanding of those concerned in the marine and ocean field.

8-2-3 Investigation Method

The following researches and investigations were carried out to attain the above purposes.

(1) Analysis of Properties of Sludge

1 Physical Properties

Grain size distribution, specific gravity and viscosity.

2 Chemical Properties

COD, oils, cyanogen, phenol and metal.

3 Biological Properties

Microbes, virus and BOD.

(2) Movement of Sludge in Ocean and Change in Quality of Sea Water

1 Settling and diffusion of sludge.

2 Conditions of sewage and change of contents in the sea-water.

3 Change of the sea-water in quality.

4 Accumulation on the sea-bed.

(3) Influence of Sludge upon Ocean Ecology.

1 Influences of different concentrations of sludge upon fishes and shellfishes.

2 Influence upon plankton and microbes.

3 Influence upon sea-bottom life.

(4) Determining Disposal Area and Method

1 Ocean current, tidal current, temperature and weather.

2 Statistics of fishery.

3 General planning of disposal area.

4 Settling and diffusion conditions.

5 Biological investigation of disposal area.

6 Depth and direction of diffusers.

7 Determination of the size of barges.

8-2-4 Investigation Results

The results of the investigation corresponding to (3) above are summarized as follows.

(1) When raw sewage is thrown into the sea, most of it settles but a little more than 10 percent of it is thought to remain suspended near surface of the sea to be gradually diffused. Experiments reveal that 13.4 percents still remain near surface 2.4 hours later and 11.0 percents 24 hours later.

(2) The settling sludge is thought to sink to the bottom, while diffusing, at the sedimentation velocity of 4.6 to 22 m/hr.

(3) Discharge of raw sludge into the sea will nourish it. To test this, seaweed was planted in sludge-charges sea-water. The result was that the seaweed grew well in a solution of raw sludge diluted up to 1:2,000 (when $NH_4 - N$ 0.1ppm and $PO_4 - P$ was 0.025ppm. approximately).

(4) Over sludge loading of 600 grams per squaremeters, the sea-water will be deteriorated within seven weeks.

(5) Concerning harmful concentration of sludge to marine life; the concentration of 2 percents proved harmless to opaleyes. When water temperature is high, even 0.1 percents may have a had influence upon short-necked clams; generally, however, marine life grows well at 0.1-percent concentration, with the exception of the larva of oysters and clams for which a concentration of not more than 0.025 percent is required.

(6) Fishes do not eat sludge by themselves. When mixed in feed, sludge was of service slightly to opaleyes but not for hamachi.

(7) For shellfishes, the concentration of sludge increase in their weight was seen in experiments at concentrations of 0.1 to 0.56 percent, if temperature is within statisfactory range.

(8) Prawns and sea cucumbers gained weight by virtue of the sludge deposited on the bottom.

(9) Animal plankton eats raw sludge. Sludge at the concentration of 5 percent proved very effective as bait to brine shrimps.

It appears that the larva of shellfishes do not eat sludge, but at a concentration not more than 0.025 percent it does not disturb them in eating bait.

(10) Excessively repeated sedimentation of sludge obviously deteriorates the sea-bottom conditions for the life and is therefore undesirable. But experiments at 0.1-percent concentration caused no apparent change in the sea-bottom ecology.

1,000 tons of sludge was dumped two times into the ocean at the position lat. 34°45'0"N and long. 139°40'0"E, 100km distant from Tokyo Bay. In each time, the dumped sludge was completely diffused in an hour when no BOD, SS and coliforms were therefore detected in that area. Sludge diffuses quickly in the ocean. There is a fair prospect, it is deemed, that discharge of sludge into the ocean will not increase the concentration of any material to such a high level as might significantly affect for submarine ecology in the ocean. Mathematic models to simulate the phenomenon of sludge diffusion in that part of the ocean are being produced. These sorts of investigation will be continued further in the future.

AGENDA

SECOND U. S. - JAPAN CONFERENCE ON SEWAGE TREATMENT TECHNOLOGY

December 1 and 2, 1972
ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ENVIRONMENTAL RESEARCH CENTER
ROBERT A. TAFT LABORATORY
CINCINNATI, OHIO

Friday, December 1

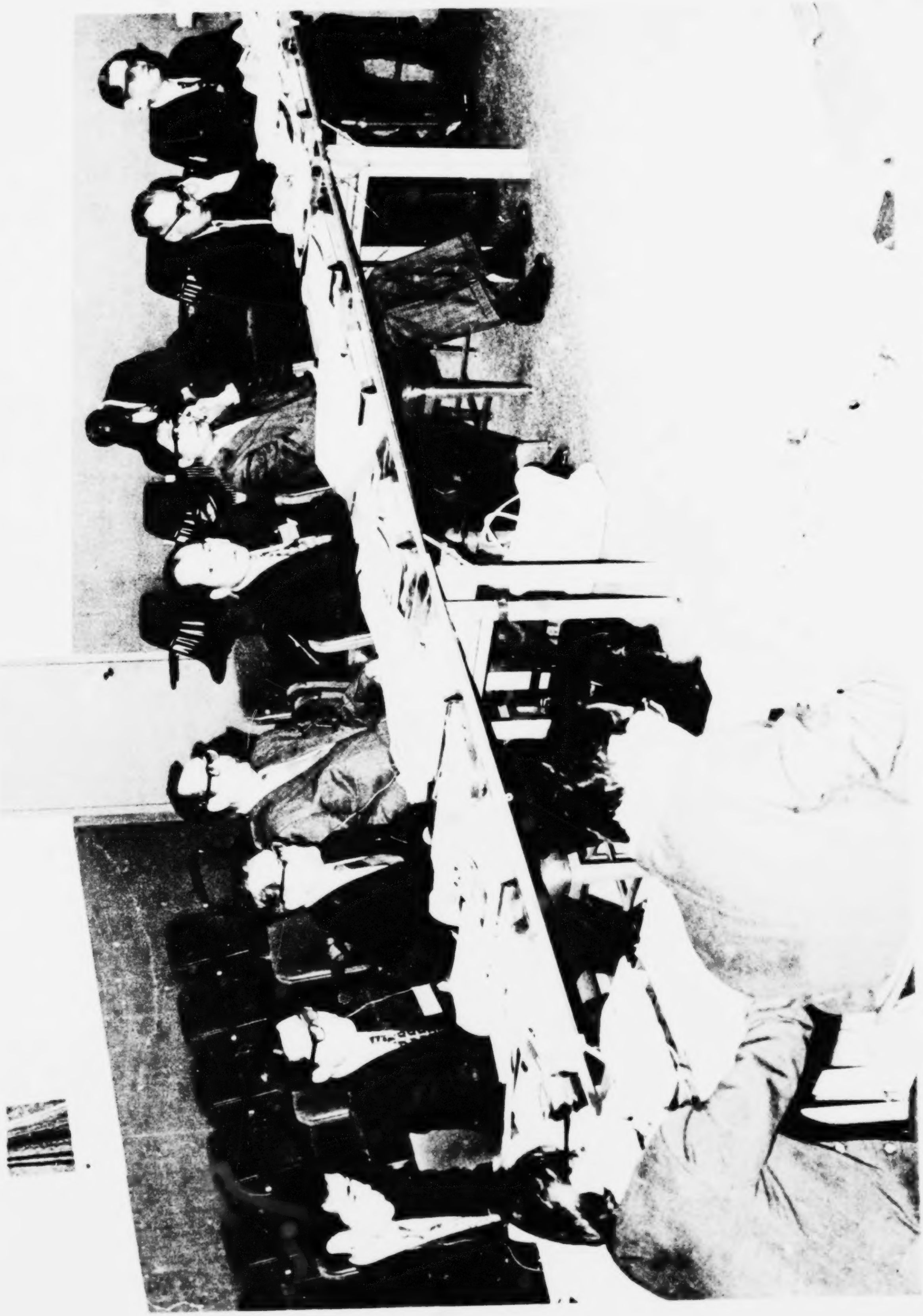
8:30 - 8:40	Welcome to NERC	Dr. A. W. Breidenbach
8:40 - 8:50	Opening Remarks and Acceptance of the Agenda	Mr. F. M. Middleton
8:50 - 9:05	Response and Remarks from Japanese Side	Dr. T. Kubo
9:05 - 9:35	Progress and Plans for Sewage Works in Japan	Dr. T. Kubo
9:35 - 10:20	Status of Research Program on Sewage Treatment Technology	Dr. M. Kashiwaya
10:20 - 10:30	Break	
10:30 - 10:50	Industrial Waste Treatment Technology in Japan	Mr. K. Hanada
10:50 - 11:10	Sludge Treatment in Tokyo	Mr. F. Hongo
11:10 - 11:30	Discussion	
1:00 - 1:15	Advanced Waste Treatment Program	Mr. J. J. Convery
1:15 - 1:45	Nutrient Removal	Mr. E. F. Barth
1:45 - 2:10	Physical-Chemical	Dr. I. J. Kugelman
2:10 - 2:35	Treatability & Upgrading	Dr. R. L. Bunch
2:35 - 3:05	Oxygen Technology	Mr. R. C. Brenner
3:05 - 3:15	Break	
3:15 - 3:45	Ultimate Disposal	Dr. R. B. Dean
3:45 - 4:00	Instrumentation and Automation	Mr. J. F. Roesler
4:00 - 4:20	Small Flow & Rural Systems	Mr. J. F. Kreissl
4:20 - 5:00	Tour of Taft Center	Mr. F. M. Middleton

Saturday, December 2

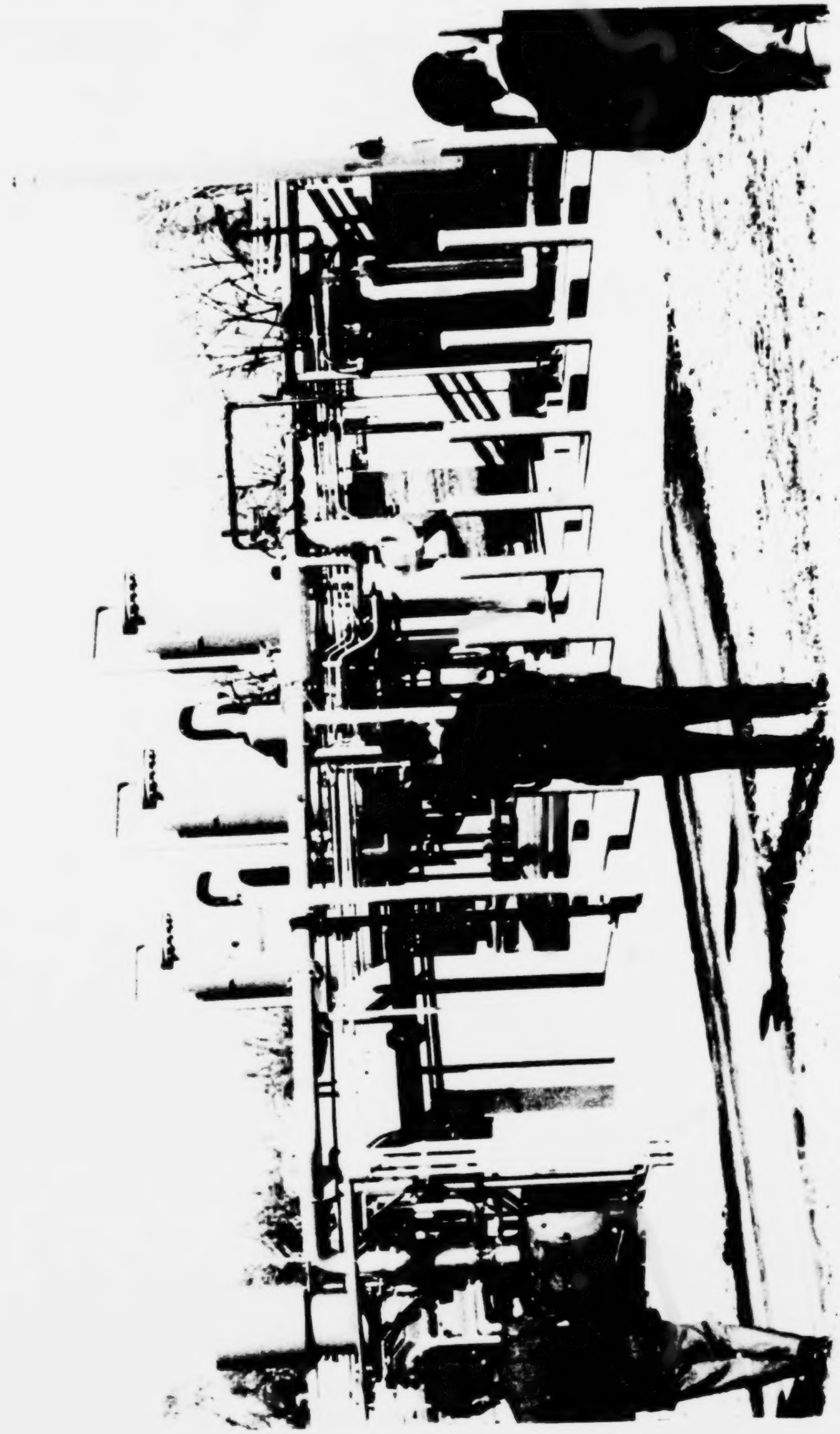
The Japanese Team along with American Team members travelled to Speedway, Indiana to visit the pure oxygen activated sludge plant in operation there. Officials from the Linde Division of Union Carbide and the City of Speedway conducted a tour of the plant.

DR. BREIDENBACH WELCOMES JAPANESE TEAM TO ROBERT A. TAFT LABORATORY

DR. KUBO OPENS CONFERENCE AT ROBERT A. TAFT LABORATORY, CINCINNATI, OHIO



JAPANESE TEAM MEETING AT ROBERT A. TAFT LABORATORY CINCINNATI, OHIO



JAPANESE INSPECT PURE OXYGEN PLANT AT SPEEDWAY, INDIANA

JAPANESE TEAM VISITS PURE OXYGEN PLANT AT SPEEDWAY, INDIANA

ADVANCED WASTE TREATMENT RESEARCH PROGRAM

John J. Convery

The Advanced Waste Treatment Research Laboratory conducts a National Program of research and development to provide new or improve existing wastewater treatment and ultimate disposal technology, achieve maximum removal of contaminants, provide cost-effective pollution control and permit repeated reuse of the Nation's waters. The laboratory currently employs 120 people and has an annual operating budget of $8.5 million dollars. Program areas include biological treatment, physical-chemical treatment, ultimate disposal, virology, mining pollution control and cost analysis. Intramural research is conducted at the National Environmental Research Center in Cincinnati and at four remote pilot plant locations. An extramural research program consisting of contracts and grants to industry and municipal governments is also conducted.

Program interest includes process research in the areas of phosphorus removal techniques, biological nitrification-denitrification, improved suspended solids removal via multi-media filtration and microstraining, disinfection with chlorination-dechlorination and ozonation, refractory organic removal with granular and powdered carbon adsorption, demineralization techniques such as reverse osmosis and ion exchange, as well as upgrading techniques such as the use of high purity oxygen aeration. Technology development is not, however, limited to process research. Odor and corrosion control in sewers through U-tube aeration and chemical additives, flow equalization, mathematical modeling, computerized cost estimating procedures and instrumentation and automation are a few of the system approaches being pursued. Basic research is being conducted on pathogen and virus enumeration techniques and development of chemical measurements of pollution or biological activity such as coprostanol and adenosine tri-phosphate (ATP). Particular emphasis is being placed on the development of sludge processing and disposal techniques for thickening, dewatering, stabilizing and disposing of sludges either by incineration or land disposal. A recent and significant accomplishment in this area has been the development of a capillary belt-pressure roller dewatering device which can concentrate waste activated sludge to 18% solids at 6 lbs/hr/ft^2 with no chemical conditioning.

New initiatives are being pursued with regard to treatability of environmentally significant pollutants such as nonbiodegradable organics and heavy metals, and testing of integrated solid waste-sludge transport and disposal techniques.

NUTRIENT CONTROL PROCESSES

Second U.S. - Japan Conference on
Sewage Treatment Technology

National Environmental Research Center-Cincinnati
Advanced Waste Treatment Research Laboratory

Cincinnati, Ohio
December 1, 1972

E. F. Barth
Chemist, Biological Treatment Research Program

NUTRIENT CONTROL PROCESSES

E. F. Barth

INTRODUCTION

The development of processes for control of nutrient elements, such as nitrogen and phosphorus, is an active area of research in wastewater treatment technology.

For the past 75 years the art of wastewater treatment was concerned with only the reactions of organic carbon compounds with oxygen. Processes for nutrient control are based on different concepts than those applied to BOD and suspended solids removal processes. During the last five years a great deal of research and development work aimed at the control of nutrients has been done. The techniques developed for the control of nutrients are closely related to the science of chemical engineering.

At the present time in the United States, the major emphasis in nutrient control is implementation of these new processes into full-scale treatment facilities.

PHOSPHORUS CONTROL

The main approach to the control of phosphorus residuals in wastewater effluents is on the use of metal salts to insolubilize the phosphorus. Using this approach any existing treatment facility can increase its efficiency of phosphorus removal. Figure 1 lists the phosphorus removal efficiency of standard type treatment processes. It is evident that the efficiency of removal is proportional to the amount of sludge produced by each process. This is the prime consideration for phosphorus control. The phosphorus must be insolubilized and removed from the system as a sludge. By adding metal precipitants to any of the processes shown in Figure 1 the efficiency of phosphorus removal can be greatly increased.

Eighty percent removal is possible at simple primary treatment plants. Figure 2 shows the results from the 3 mgd plant at Mentor, Ohio. Provision was made to add ferrous chloride to the existing primary settler, a small amount of base to control pH, and an anionic polymer. At primary plants

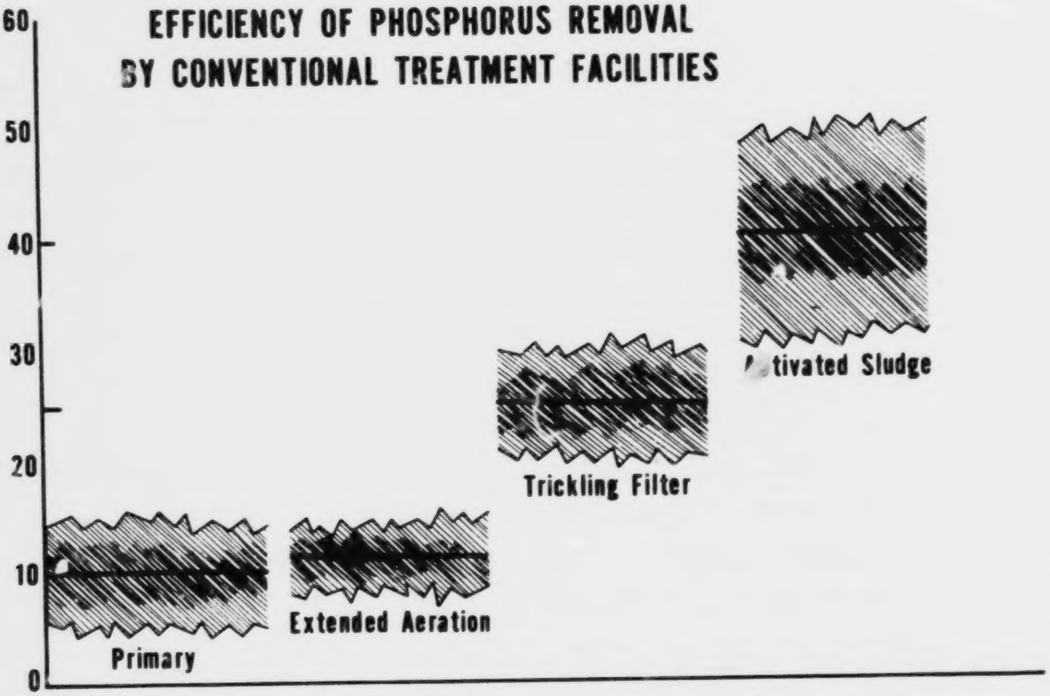


Figure 1. TYPE OF TREATMENT

	PERCENT REMOVAL		
CHEMICAL ADDED	SS	BOD	TOTAL PHOSPHORUS
None	37	24	10
$FeCl_2$, 43 mg/l (as Fe) Lime, 66 mg/l Polymer, 0.4 mg/l	74	59	83

Figure 2. CHEMICAL ADDITION TO A PRIMARY TREATMENT PLANT, MENTOR, OHIO (3mgd)

polymer must be used because the insolubilized phosphorus compounds are colloidal in nature and will not settle by gravity unless the particles are agglomerated. Two milligrams per liter residual phosphorus is the best efficiency that can be obtained by chemically dosing a primary settler because complex phosphates are present, and these do not precipitate with metal salts.

At existing secondary plants phosphorus removal can be accomplished by arranging for the dosing of metal salts into the biological unit or between the biological unit and the final sedimentation tank. Figure 3 shows this flow scheme. At activated sludge plants the mixed liquor aerator can be dosed at either the head end or mixed liquor outlet. At trickling filter plants the filter underdrain is dosed in a flash mix chamber, just before entrance into the final sedimentation basin. In these cases there is only a small investment in capital construction cost. The equipment needed consists of chemical dosing pumps, chemical storage tanks and perhaps flow pacing and monitoring equipment.

Figure 4 shows the results obtained at the 1 mgd Texas City, Texas, activated sludge plant. Ferric chloride was added to the aerator at a mole ratio of 1.7:1 of iron to phosphorus. The phosphorus was effectively insolubilized. The soluble phosphorus in the effluent never exceeded 0.5 mg/l. However, the total iron content of the final effluent is dependent on the solids capture efficiency of the final sedimentation basin. At surface overflow rates less than 900 gallons per day per square foot, effluent total phosphorus residuals are usually in the range of 1 mg/l. These two residual levels are critical from a design standpoint. A residual total phosphorus level of 1 mg/l can be obtained by chemical dosing at any activated sludge or trickling filter plant if the final sedimentation basin has a surface overflow rate less than 900 gpd/ft^2. If the effluent requirement is less than 1 mg/l, for instance 0.5 mg/l, no matter what the overflow rate, a filtration process will have to be installed. This, of course, would require additional capital cost.

The cost of phosphorus removal is largely an operating cost. To effectively and economically control phosphorus at large treatment facilities a control system should be installed to accurately dose metal salts in relation to phosphorus loading. Figure 5 shows a dual open loop, feed forward, control

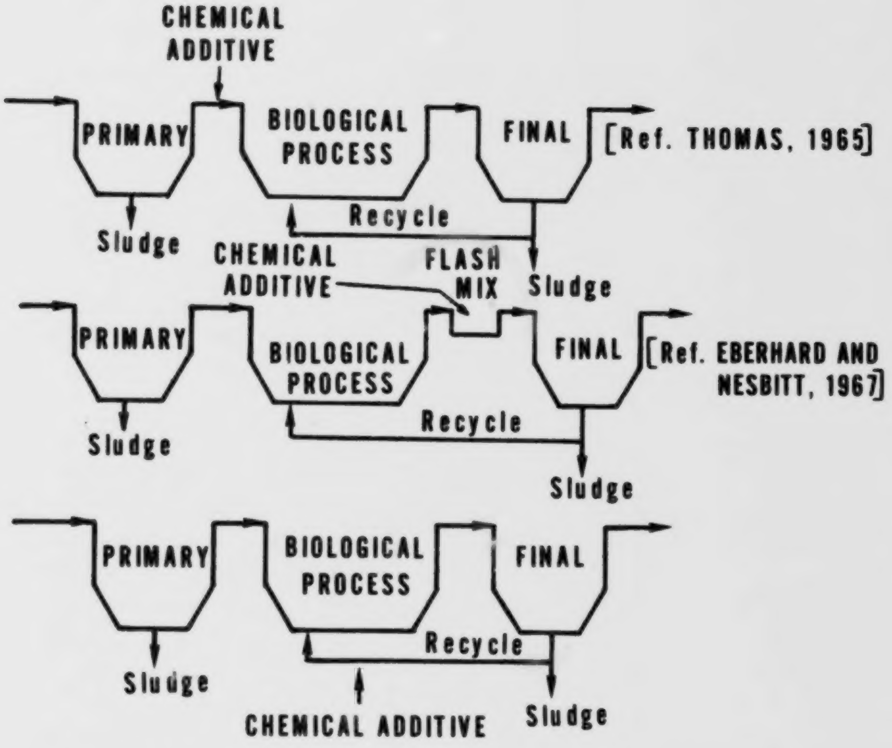
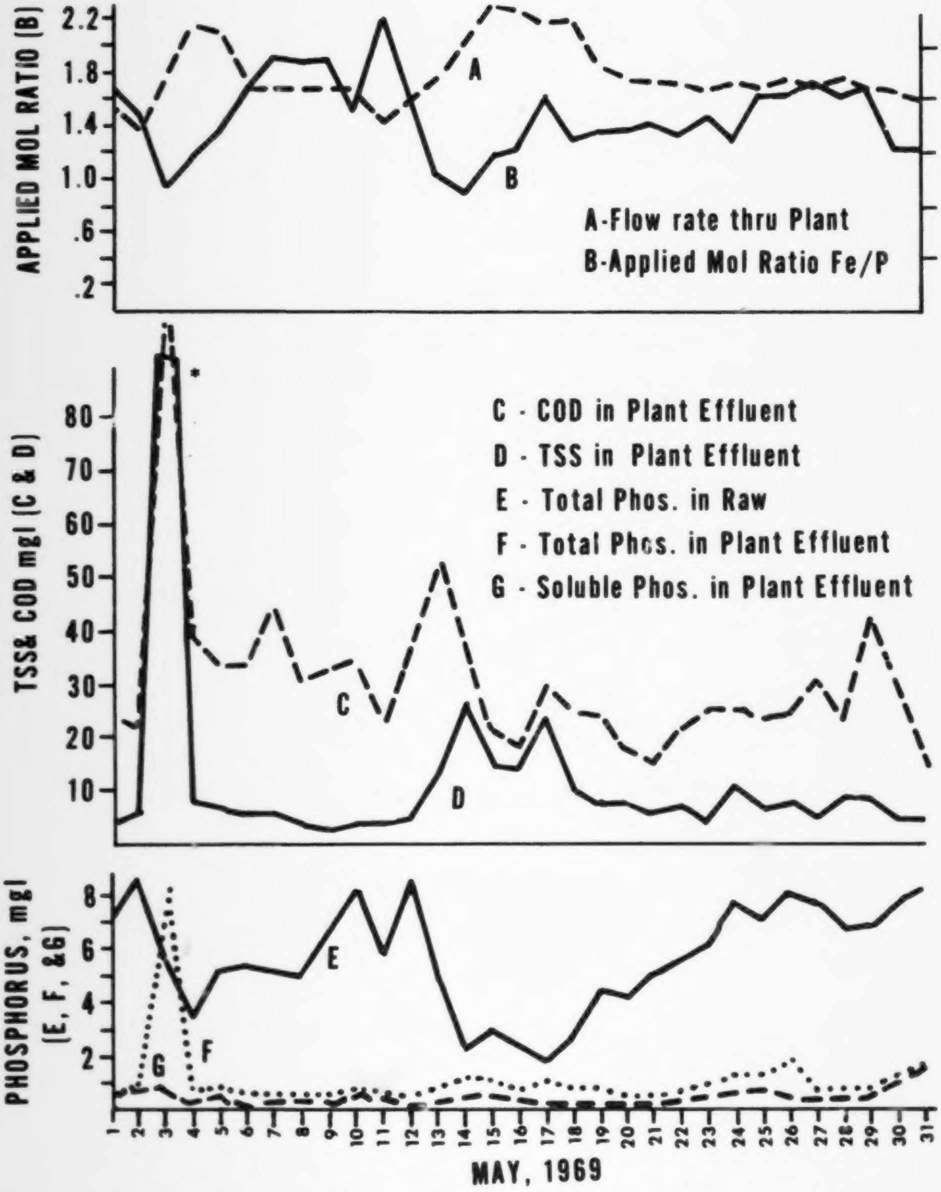


Figure 3. COMBINED CHEMICAL -BIOLOGICAL, VARIATIONS OF BASIC SYSTEMS



*on May 3, inadvertant acceptance of 1.5-1.6 MGD rate for 2-3 hours, raised effluent COD, suspended solids and phosphorus for the day to 108, 141, and 8.3 mg/l respectively.

Figure 4. FERROUS IRON INJECTION TO RAW EFFLUENT, TEXAS CITY PLANT NO.2, MAY 1969

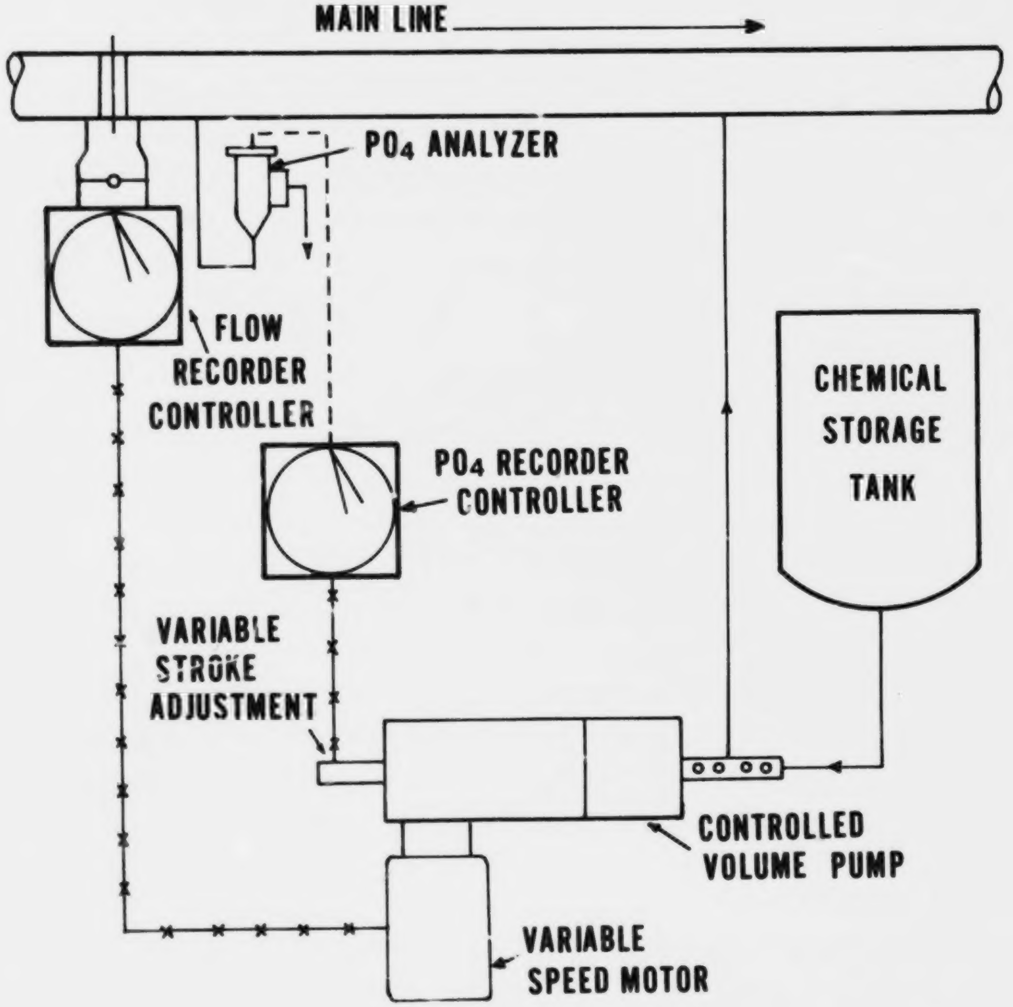


Figure 5. DUAL AUTOMATIC OPEN LOOP CHEMICAL FEED SYSTEMS FOR CONTROLLED DOSING

system that has been designed into several facilities in the United States. Figure 6 shows that from a total treatment cost standpoint, the percent increase due to implementating phosphorus removal varies with the size of the treatment facility. This is because metal salts are bulk chemical comodities, and there is no real cost reduction for large purchases. Chemical purchase offers no economy of scale factor. A small 1 mgd facility will experience about a 25 percent increase in total treatment cost. A large 100 mgd facility will experience about a 50 percent increase in total treatment cost when phosphorus removal is included with BOD and suspended solids removal.

NITROGEN CONTROL

Nitrogen control processes are a complex mixture of bacteriological, chemical, and engineering considerations. Nitrogenous materials can have a great influence on environmental parameters, as shown on Figure 7.

A very critical decision that environmental planners must make is to decide if the solution to a nitrogen problem can be solved by controlling the chemical form of nitrogen discharged in an effluent, or whether a complete nitrogen removal process is necessary. If ammonia nitrogen in an effluent causes dissolved oxygen problems in a receiving water, it would only be necessary to produce a nitrified effluent to solve the problem. Nitrogen removal would not be needed. Figure 8 shows how important the oxygen demand due to ammonia nitrogen is in relation to the total oxygen demand of an effluent.

Figure 9 shows that a nitrified effluent is desirable for two additional reasons. A nitrified effluent with a small residual ammonia content can be breakpoint chlorinated to eliminate all traces of fish toxicity due to chloramines. An effluent with only 2 mg/l of ammonia nitrogen requires only 20 mg/l of chlorine to reach breakpoint; whereas an effluent with 20 mg/l of ammonia nitrogen would require in excess of 150 mg/l of chlorine to reach breakpoint. Due to the fact that low doses of chlorine can be applied to a nitrified effluent to produce a free chlorine residual, the disinfecting properties of chlorine are enhanced and shorter contact times are effective in regards to disinfecting ability.

COSTS IN DOLLARS PER MIL GAL TREATED

	PLANT SIZE - MGD		
	1	10	100
CURRENT ANNUAL OPERATING COSTS FOR CARBON AND SOLIDS REMOVAL INCLUDING DEBT RETIREMENT	233	135	82
CHEMICAL COST FOR 90% PHOSPHORUS REMOVAL USING LIQUID ALUM - INFLUENT PHOSPHORUS = 10 mg/1 P	35	35	35
ADDITIONAL DEBT RETIREMENT AND O & M COSTS FOR PHOS. REMOVAL	25	10	5
TOTAL INCREMENTAL COSTS FOR PHOSPHORUS REMOVAL	60	45	40
TOTAL ANNUAL OPERATING COSTS FOR CARBON, SOLIDS AND PHOSPHORUS REMOVAL	293	180	122
% INCREASE IN TREATMENT COSTS FOR PHOSPHORUS REMOVAL	26	33	49

Figure 6. ESTIMATED TOTAL TREATMENT COSTS ACTIVATED SLUDGE TREATMENT PLUS PHOSPHORUS REMOVAL JANUARY 1970

IMPORTANCE OF NITROGEN

NH_3 IN EFFLUENTS CAN CAUSE DO
SAG IN RECEIVING WATER

NH_3 IS CORROSIVE TO COPPER FITTINGS

1 NH_3 REQUIRES 7 PLUS CL_2 FOR
BREAKPOINT

NH_3 INFLUENCES CL_2 CONTACT TIME

NH_3 CAN BE TOXIC TO FISH

NO_2 CAUSES HIGH CL_2 DEMAND

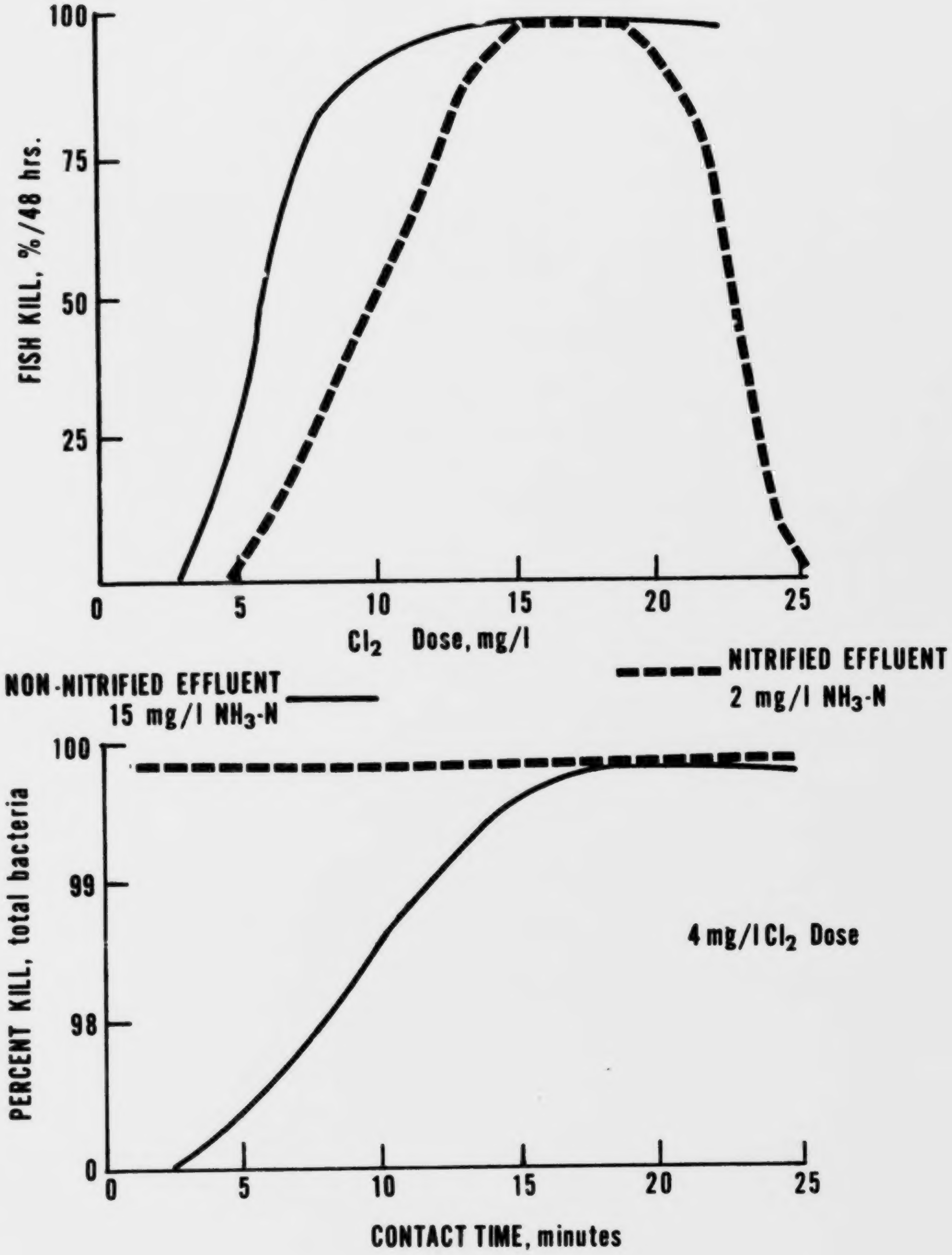
NITROGEN COMPOUNDS ARE
NUTRIENTS

NO_3 CAN BE HEALTH HAZARD

Figure 7.

	mg/l WASTEWATER	mg/l FINAL EFFLUENT
ORGANIC MATTER	250	25
ORGANIC OXYGEN DEMAND	375	37
NH_3	25	20
AMMONIA OXYGEN DEMAND	112	90
TOTAL OXYGEN DEMAND	487	127
PERCENT OF OXYGEN DEMAND DUE TO NH_3	22%	71%

Figure 8. RELATIONSHIP OF CARBONACEOUS OXIDATION AND AMMONIA OXIDATION, BEFORE AND AFTER TREATMENT TO REMOVE 90% OF CARBONACEOUS MATERIAL



100
75
50
25
0
FISH KILL, %/48 hrs.
0
5
10
15
20
25
Cl_2 Dose, mg/l
NON-NITRIFIED EFFLUENT
15 mg/l NH_3-N
NITRIFIED EFFLUENT
2 mg/l NH_3-N
100
99
98
0
PERCENT KILL, total bacteria
4 mg/l Cl_2 Dose
0
5
10
15
20
25
CONTACT TIME, minutes

Figure 9.

Because nitrogen compounds are so important to the environment, many control processes have been investigated. Figure 10 lists the most thoroughly studied processes. It should be noted that each of these processes requires that the nitrogenous material be present in a specific ionic form. This is an important engineering consideration for highly efficient processes. Nitrogen present in the form of nitrate ion would not be removed by an ammonia stripping process.

The last process listed on Figure 10 represents biological denitrification. This is the nitrogen control process which has been studied most exclusively in the United States. Many large treatment plants such as the 50 mgd Tampa, Florida, and the 309 mgd Washington, D.C., facilities are currently under construction for implementation of this process.

As indicated in Figure 11, biological systems transform nitrogenous compounds into various chemical forms. A three-stage system, as depicted in Figure 12, allows these various reactions to be controlled efficiently. The first stage removes the carbonaceous material as carbon dioxide and waste activated sludge. This can be designed as a high rate activated sludge process or a trickling filter process. A lime coagulation process could also be employed to remove the particulate organic material. The key point of this first stage is that organic carbon is removed before the wastewater flows to the second stage. In order to control nitrification in the second stage there must be a long cell residence time because the nitrifying organisms have a very long cell reproduction rate. This separation of carbonaceous removal and nitrification into two separate unit processes is the engineering solution to reliable nitrification.

After the second stage nitrification the wastewater flows to a third stage where biological denitrification occurs. This is an anoxic stage that is mechanically stirred to insure contact of microorganisms and substrate. To force the facultative organisms such as Pseudomonas to utilize the oxygen reserves in the nitrate radical, an organic supplement must be added to serve as a hydrogen donor in the denitrification reaction. The products of the reaction between the nitrate and organic material are carbon dioxide and nitrogen gas, both of which are acceptable for discharge to the atmosphere.

NITROGEN REMOVAL PROCESSES

$$NH_3^\circ\text{(SOLUTION)} \xrightarrow{\text{air}} NH_3^\circ\uparrow \text{ (GAS)}$$

$$NH_4^+ \longrightarrow \text{CLINOPTILOLITE} \bullet NH_4$$

$$NO_3^- \longrightarrow \text{RESIN} \bullet NO_3$$

REVERSE OSMOSIS

ELECTRODIALYSIS

DISTILLATION

$$2\ NH_3 + 3\ CL_2 \longrightarrow N_2^\circ\uparrow + 6\ HCL$$

$$NO_3^- + Fe^{++} \xrightarrow{Cu} N_2^\circ\uparrow + Fe^{+++}$$

$$NO_3^- \xrightarrow[\text{organisms}]{\text{organic C}} N_2^\circ\uparrow + CO_2$$

Figure 10

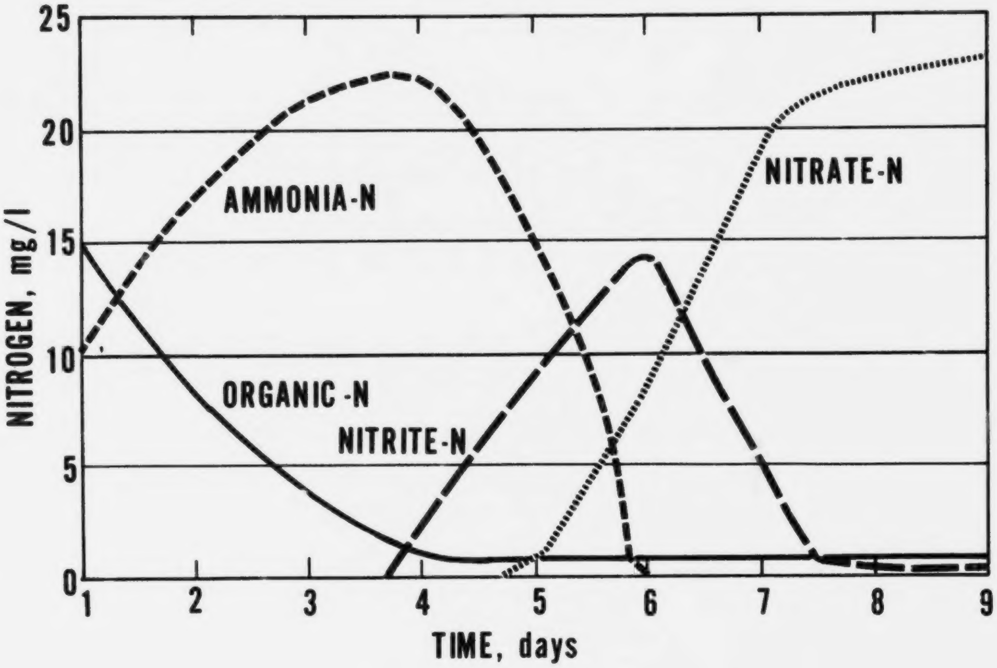


Figure 11. NITROGEN TRANSFORMATIONS

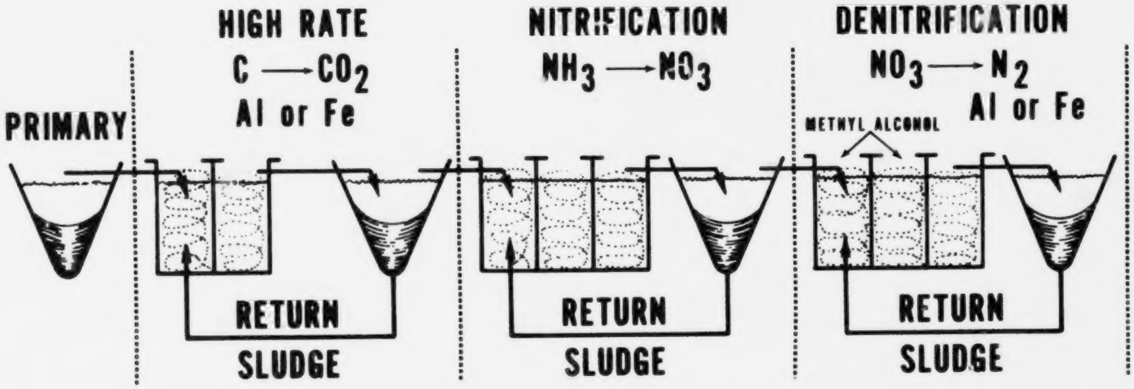


Figure 12. THREE SLUDGE SYSTEM FOR NITROGEN REMOVAL

The organic material that has been selected as most suitable for denitrification is methanol. This process has been demonstrated at several locations including Manassas, Virginia, and Contra Costa, California. Results of the Manassas study are given on Figure 13.

The initial concept of a three-stage system has spanned alternate processes for each of the stages. The first stage can be activated sludge, trickling filter, or a chemical coagulation. The second stage can be activated sludge or trickling filter. The third stage can be suspended growth or towers packed with either fine or course media. Figure 14 shows the three variations of the third stage denitrification process. Engineering judgement is necessary to determine which configuration would best suit a particular treatment need.

CONSTITUENT	FINAL SETTLER, mg/l	AFTER FILTRATION, mg/l
Suspended Solids	6	1
BOD_5	6	1
COD	22	16
Total Phosphorus	0.5	0.3
Organic-N	1.5	1.2
NO_2-N	0	0
NO_3-N	0.9	0.8

Figure 13. EFFLUENT CONCENTRATIONS OF NUTRIENTS MANASSAS, VIRGINIA (0.2 mgd)

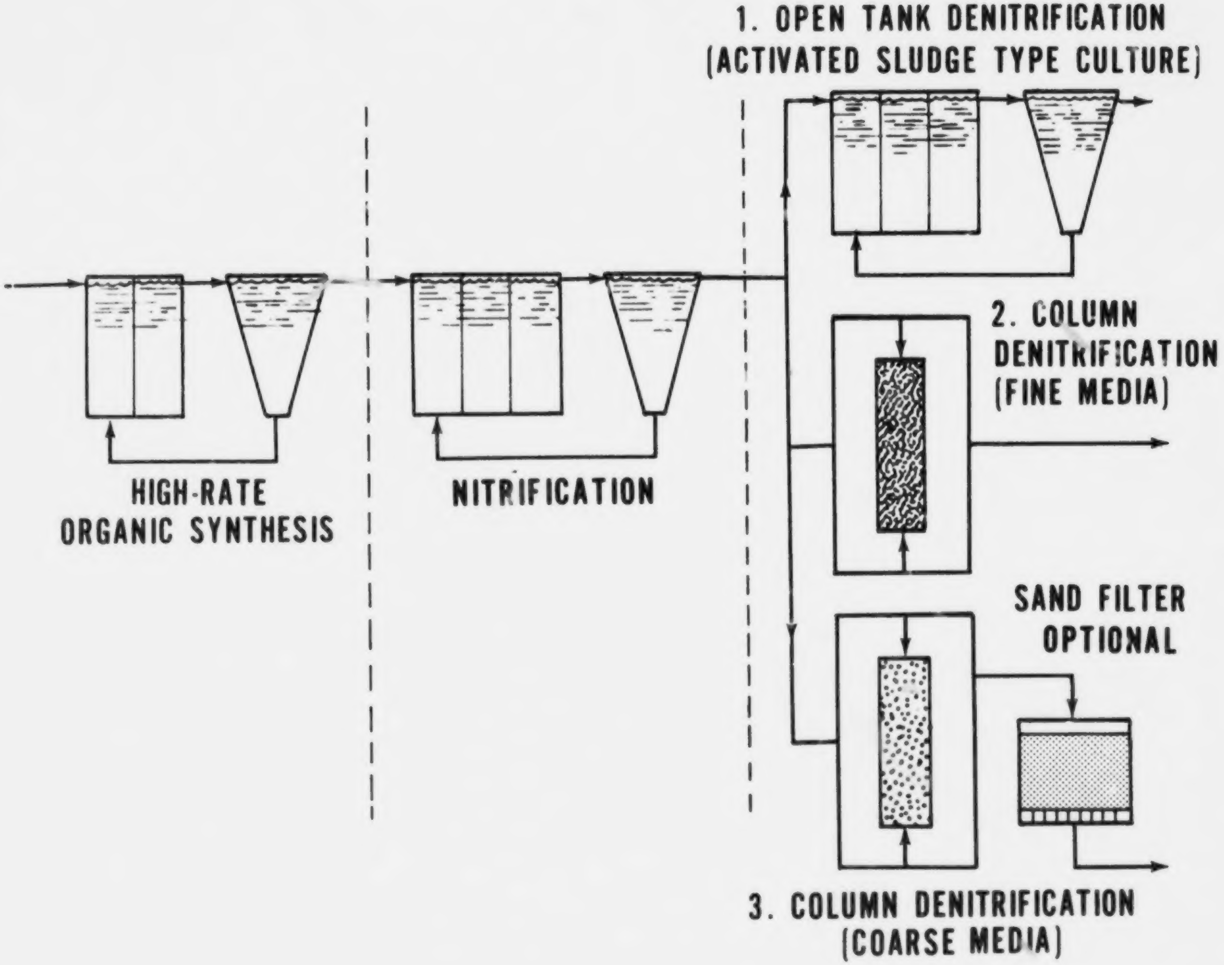


Figure 14. MODIFICATIONS OF THE DENITRIFICATION PROCESS

PHYSICAL-CHEMICAL PROCESSES

I. J. Kugelman and J. M. Cohen

INTRODUCTION

The most recent advance in the art of sewage treatment is the application of physical-chemical technology to raw sewage treatment. In reality, physical-chemical treatment of sewage is not a completely new technology. Chemical treatment of sewage was widely practiced in England and the United States in the latter portion of the 19th Century. However, this technique gradually fell into disuse with the advent of activated sludge, because activated sludge systems achieved higher degrees of treatment (1). In the 1930's a number of systems employing physical and chemical treatment in combination were evaluated. These produced treatment superior to primary sedimentation followed by activated sludge (conventional treatment) but at a cost 1.5 to 2 times as great (2). This additional increment of cost discouraged adoption of physical-chemical treatment at that time.

During the last decade advances in physical-chemical treatment technology resulting from Environmental Protection Agency-supported research have significantly reduced the cost of physical-chemical treatment. In addition, it is apparent that higher levels of treatment will be required in the future to maintain water quality. As a result of these alterations in conditions, physical-chemical treatment is now an alternative to conventional treatment, especially for situations where significant phosphorus removal is required.

GOALS OF SEWAGE TREATMENT

The fundamental goal of sewage treatment is sufficient reduction in the level of pollutants in the wastewater to allow discharge to the environment. The pollutants in sewage are grouped into classes of similar compounds which have the same environmental impact rather than being individually dealt with. At present the five major pollutant groups of interest are: suspended solids, organic matter as measured by BOD, TOC or COD, phosphorus compounds, nitrogen compounds and pathogenic microorganisms. It is impossible to specify one set of effluent standards which is applicable to all or most situations. However, it is generally agreed that a good quality effluent will have the characteristics given in Table 1. In addition, complete disinfection will be required. As yet no general agreement on a nitrogen level is in evidence. It must be repeated the goals listed above are not design standards, but are guides in describing a good quality effluent.

THE CLARIFICATION-ADSORPTION PROCESS

The physical-chemical treatment system which at present is most advanced in development, and which seems the best is the clarification-adsorption system schematically illustrated in Figure 1. In this system chemical clarification and filtration are utilized to achieve almost complete suspended and colloidal solids removal. With a high enough dose of the proper chemicals essentially complete phosphorus removal can also be obtained. The function of the activated carbon step is the removal of soluble organics. As in any conventional system preliminary screening, grit removal and final disinfection are provided. The filtration step is shown as optional but conservative design dictates its use. The positioning of this step prior to or after carbon adsorption is dictated by the type of waste-carbon contacting system provided. The three steps of chemical clarification, filtration and carbon adsorption will be discussed in some detail below.

This system does not provide ammonia or nitrate-nitrogen removal. Physical-chemical methods for soluble nitrogen removal are covered in another lecture of this symposium. Any of these nitrogen removal methods can be integrated into the clarification-adsorption system.

CHEMICAL CLARIFICATION

Chemical clarification provides the bulk of the pollutant removal achieved by this type of treatment system. In this unit operation an appropriate chemical is dosed to the wastewater and the mixture is flocculated and settled. All of these steps can be conducted in independent units, or combined into a single unit which is usually referred to as solids-contact clarifier.

Chemicals which have been successfully used to clarify raw sewage include organic polymers (3), iron salts (4), aluminum salts (5), and lime (6)(7). The inorganic coagulants have the advantage of providing for phosphorus removal. At present there is no rational method for predicting the dose of chemical required. For planning purposes, jar tests are suggested. Fortunately field control of the coagulant dose is possible. For all coagulants except lime the suggested method is monitoring of the clarifier effluent turbidity. Monitoring of phosphorus also appears promising, as good clarification is always obtained when sufficient chemical is added to provide good phosphorus removal. With lime as the coagulant excellent control is obtained by pH measurement. The pH required to achieve good clarification and phosphorus removal is dependent on the chemical characteristics of the sewage. In areas where the alkalinity and hardness are low the high lime process in which the pH is raised to approximately 11.5 is required. Generally, two-stage precipitation with intermediate recarbonation is utilized. In hard water, high alkalinity areas a low lime single-stage precipitation at pH 9.5 to 10 is sufficient.

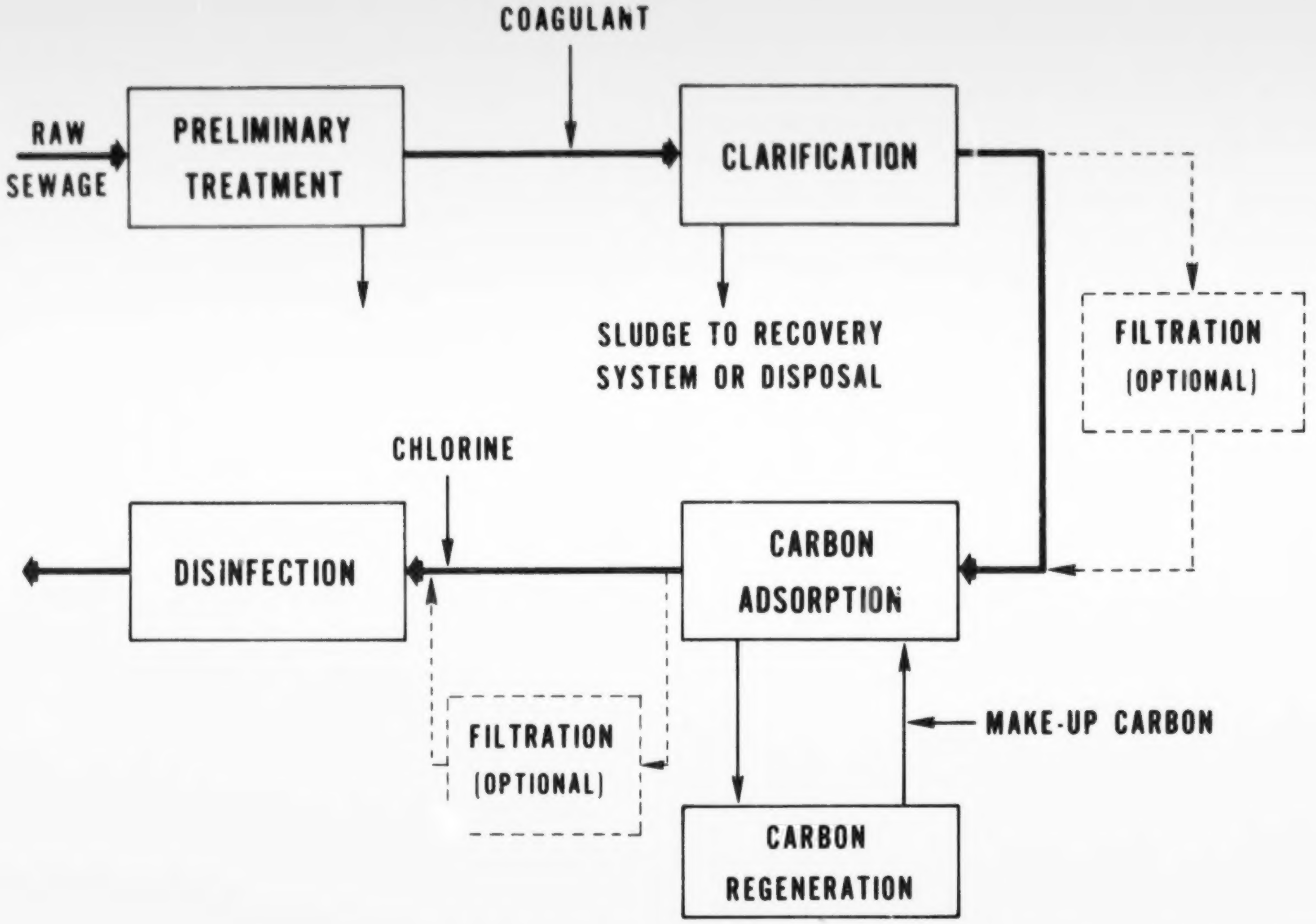


Figure 1. FLOW DIAGRAM OF A PHYSICAL-CHEMICAL TREATMENT SYSTEM

Table 1. DESIRED EFFLUENT QUALITY

BOD	10 MG/L
COD	60 MG/L
SS	10 MG/L
P	1 MG/L

Table 2. ACHIEVEMENTS OF CHEMICAL CLARIFICATION

PLANT	CHEMICAL	ORGANIC REMOVAL %	SS REMOVAL %	P REMOVAL %
EWING-LAWRENCE	170 mg/l $FeCl_3$	80	95	90
NEW ROCHELLE (ZM)	LIME pH 11.5	80	98	98
WESTGATE, VA.	125 mg/l $FeCl_3$	70	-	-
SALT LAKE CITY	80-100mg/l $FeCl_3$	75	-	80
BLUE PLAINS	LIME pH 11.5	80	90	95

Table 2 illustrates the treatment obtained with chemical clarification in pilot plants at a variety of locations. In addition to the expected high levels of suspended solids and phosphorus removal significant organic removal was obtained. Based on these data and others it can be expected that chemical clarification of raw sewage will consistently yield organic removal in the 65-75 percent range. With this degree of organic removal from chemical coagulation the carbon need provide only a small increment of additional removal to match the performance of a good secondary treatment system.

Sludge disposal plays a dominant role in the economics of any chemical clarification system. Only limited data on the characteristics of sludges resulting from the chemical treatment of raw sewage are available. These data indicate that with iron or aluminum salts as coagulants:

1. The resulting sludge volume sometimes exceeds and sometimes is less than primary sludge from the same sewage.

2. The chemical sludge is more difficult to dewater in a vacuum filter than the corresponding primary sludge.

However, with lime as the coagulation chemical dewatering is extremely rapid just by gravity thickening. Eimco (8) reported lime-raw sewage sludge solids concentrations of 15% to 25% after gravity thickening.

In addition to yielding a sludge amenable to rapid and easy dewatering lime is the only coagulation chemical which can be economically recovered. Recalcining the lime sludge in a furnace has been successfully conducted in a tertiary plant at South Lake Tahoe and has been state-of-the-art in water softening plants for a considerable period of time (9). In addition to regenerating the lime, the organic solids are incinerated thereby accomplishing ultimate disposal of the sludge. For these reasons it is anticipated that lime will be the coagulant of choice for most situations.

Design criteria for the coagulation equipment is similar to that used in water treatment plants. A flash mix of one minute, flocculation for 15 to 30 minutes and sedimentation at upflow rates of 0.5 and 1.0 gpm/ft^2.

CARBON ADSORPTION

The role of the carbon adsorption step is the removal of soluble organics from the wastewater. Although the chemical clarification step does the bulk of the pollution control job, the carbon adsorption step is required to produce a good quality effluent. The total organic removal achieved by the combination of clarification and carbon adsorption at several physical-chemical pilot plants is illustrated in Table 3. It can be seen that not only is the removal achieved quite high (95%+) but equally important the residual organics after treatment are quite low. These effluents are superior to the usual quality of secondary effluent (TOC $\approx$ 20 mg/l, COD $\approx$ 40 to 50 mg/l).

The results reported in Table 3 were obtained with carbon contacting systems employing granular carbon. In such systems the waste is passed either upward or downward through columns containing the carbon. Downflow columns function as packed beds and accomplish filtration of the wastewater. Flow rates of 2 gpm/ft^2 to 8 gpm/ft^2 have been employed. In this flow range essentially equivalent adsorption efficiency is obtained provided the same contact time is employed. At flow rates below 2 gpm/ft^2 adsorption efficiency is reduced, while at flow rates above 8 gpm/ft^2 excessive pressure drop takes place. Contact times employed are in the range of 30 minutes to 60 minutes on an empty bed basis. In general increases in contact time up to about 30 minutes yield proportionate increases in organic removal. Beyond 30 minutes the rate of increase falls off with increases in contact time and at about 60 minutes contact becomes negligible. Carbon beds to be operated at the lower end of the flow rate range are generally designed for gravity flow. Those systems designed for the higher flow rates employ pressure vessels. A pressure vessel is more expensive to contruct than a gravity flow vessel but it requires less land area, and provides greater ability to handle fluctuations in flow rate.

Provision must be made to periodically backwash downflow carbon beds because even if they are preceded by a filter they gradually collect suspended solids. In addition, biological growth takes place on the carbon granules and tends to clog the bed. It is advisable to include a surface wash and air scour to be assured of removal of the gelatinous biological growth.

Backwash of the carbon beds satisfactorily relieves clogging but does not completely remove the biological growth. Consequently, significant biological activity is manifest in the carbon beds at most times. This leads to the development of anaerobic conditions in the carbon bed and generation of sulfides. Aeration of the column feed has been utilized to prevent anaerobic conditions, but this produced so much biological growth that excessive backwash was required.

In an attempt to overcome these difficulties upflow carbon columns have been operated in a slightly expanded mode (about 10% expansion). This allows for significant accumulation of biological activity on the carbon granule with little increase in head loss. Consequently, aerobic conditions can be maintained and sulfide generation prevented.

If the expanded bed system is utilized backwash facilities must still be provided as it has been found necessary to occasionally remove excess growth. With this system the flow rate range which can be used is more restricted than with packed bed systems. With the commercial sizes of carbon available (8x30 mesh or 16x40 mesh) flow rates above 4 to 5 gpm/ft^2 are required to achieve the proper degree of expansion. In addition, care must be exercised to avoid hydraulic surges which could wash carbon out of the system. The filtration section of the physical-chemical treatment plant must follow carbon contact when the expanded bed system is used.

The latest carbon contacting scheme to be applied to waste treatment utilizes powdered carbon (particle size below 200 mesh). This procedure provides for a mixture of a carbon slurry and the wastewater in a Reactor-Clarifier. Polymer addition is generally required to achieve a good gravity separation of the carbon from the wastewater following contact. The potential advantages of this system are the use of a cheaper carbon (10¢ per pound vs. 30¢ per pound for granular carbon) and a simpler type of contacting system.

A critical aspect of the design of any carbon contacting system is the expected capacity of the carbon for the organics. In the chemical processing industries this is evaluated by running adsorption isotherm tests. In the waste treatment field isotherms are of limited utility because the biological activity which develops on the carbon tends to greatly enhance its apparent capacity for organic removal.

The role of the design engineer is to utilize a system which makes greatest utility of the capacity of the carbon regardless of what the capacity is. In order to provide a good effluent and utilize most of the available capacity, countercurrent contact is required. This is achieved by having the waste flow through a number of contactors or stages in series in one direction, while the carbon moves in the opposite direction. In the powdered carbon contacting system this is exactly the procedure used. With granular carbon this procedure cannot be used as undesirable attrition losses will take place. Rather when an undesirable effluent is obtained the lead contactor is removed from service and a spare contactor with fresh carbon placed at the end of the line. Each contactor is then moved up one position in the line. This is accomplished by piping and valving a series of columns to shift the inflow and outflow points of the series accordingly rather than physically moving the columns. As the number of stages increases, the piping and valving arrangement becomes more complex and costly. In design, a compromise between the advantage of adding another stage to more closely approach the highest use of the carbon capacity, and the cost of each additional stage must be achieved.

An alternate arrangement which is used in some plants provides parallel flow through a number of identical contactors. Each is at a different stage of exhaustion and produces a slightly different effluent quality. These individual effluents are blended to produce the final product.

Table 4 reviews the various factors which must be considered in designing any carbon removal system.

In Table 5 carbon capacities obtained in field operation at various pilot plants are given. In view of the fact that the waste, effluent criteria, number of contact stages etc., varied from plant to plant it is not surprising that some spread in the results is observed. These capacities are expressed as pounds of organics removed (either as COD or TOC) per pound of carbon. For general planning purposes a capacity of 0.5 pounds of COD per pound of carbon is reasonable. This is approximately equivalent to a requirement of 500 pounds of activated carbon per million gallons of sewage treated.

TABLE 3. TOTAL TREATMENT P-C PLANTS

PLANT	ORGANIC REMOVAL %	EFFLUENT CONCENTRATION
BLUE PLAINS	95-98	TOC=6
LEBANON	95	TOC=11
EWING-LAWRENCE	95-98	TOC=3-5
NEW ROCHELLE	95	COD=8

Table 4. CONSIDERATIONS IN CARBON TREATMENT DESIGN

1. **TYPE OF CARBON-GRANULAR OR POWDERED**
2. **CONTACT TIME**
3. **FLOW RATE**
4. **CONFIGURATION-SERIES OR PARALLEL**
5. **NUMBER OF STAGES**
6. **FLOW DIRECTION - PACKED OR EXPANDED**
7. **HYDRAULIC FORCE - PUMPED OR GRAVITY**
8. **ORGANIC CAPACITY**

Table 5. CARBON CAPACITY IN P-C TREATMENT PLANTS

PLANT	CARBON CAPACITY	
	LBS TOC / LB A.C.	LBS COD / LB A.C.
BLUE PLAINS	0.15	0.41
EWING-LAWRENCE	0.3	–
NEW ROCHELLE(ZM)	–	0.6
LEBANON	0.22	0.5

A carbon requirement at this level would be prohibitively expensive if regeneration and reuse of the exhausted carbon were not possible. At present a technically and economically feasible method is available for the regeneration of granular activated carbon. This method requires heating of the carbon in a multi-hearth furnace in the presence of steam to ≈ 1750°F. This treatment burns away the adsorbed and trapped organics. During a regeneration cycle some of the carbon is physically lost by burning and attrition, and some of each particle's capacity is lost by alteration of surface properties. The overall loss expressed as percent by weight of virgin carbon required to restore the total original capacity of the batch ranges from 5 to 10 percent (10). Thus, for planning purposes carbon make-up requirements at a plant should range from 25 to 50 lbs per million gallons of sewage treated.

At present experiments on a fluidized bed regeneration system for powdered carbon are moving into the large-scale pilot stage. Successful completion of these tests will be a big step forward in making a powdered carbon system a technical and economic reality. The key factor will be maintaining the carbon loss at a low enough level during the regeneration.

DESCRIPTION & PERFORMANCE OF SOME PHYSICAL-CHEMICAL PILOT PLANTS

In the previous sections of this paper summaries of performance from a variety of physical-chemical treatment plants were presented. In this section a somewhat more detailed look will be taken at a selection of these plants.

Ewing-Lawrence (4)

For the last several years FMC Corporation has been conducting studies of physical-chemical treatment at the Ewing-Lawrence Treatment Plant near Princeton, N.J. Figure 2 illustrates the clarification section of the plant. These units were somewhat overdesigned to insure a good feed to the adsorption section of the plant, as the major purpose of the research was to evaluate carbon performance. Figure 3 is a schematic of the overall plant. Packed bed versus expanded bed carbon contact in parallel was studied at this plant. Figure 4 indicates that the performance of the packed bed contactor was slightly superior to that of the expanded bed contactors. However, the investigators indicated that the advantage was not sufficient to offset the need to backwash more frequently and the potential difficulties from anaerobic conditions in the carbon beds. Figure 5 illustrates the BOD removal obtained over a 3-1/2 month period. It can be seen that despite considerable variation in influent strength a consistently good effluent was produced. This figure also reiterates that the bulk of the treatment is accomplished in the chemical clarification step.

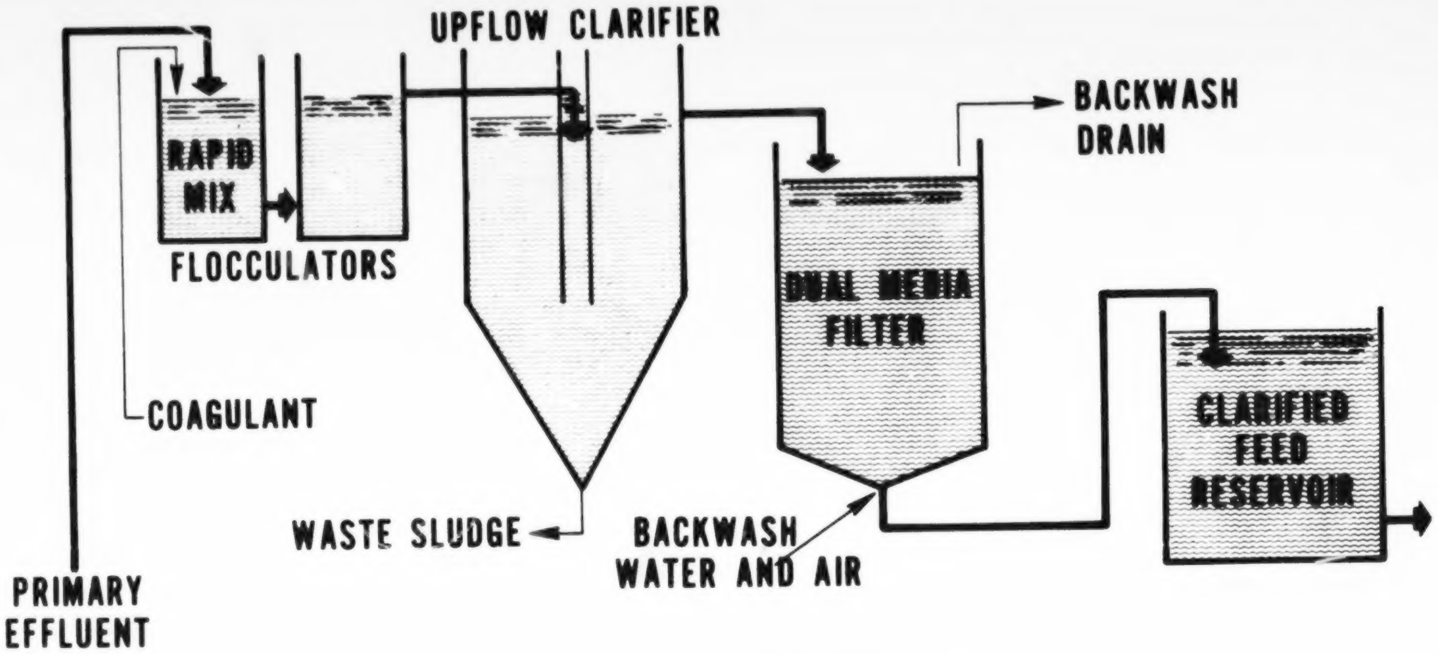


Figure 2. FLOW DIAGRAM OF CLARIFICATION SYSTEM

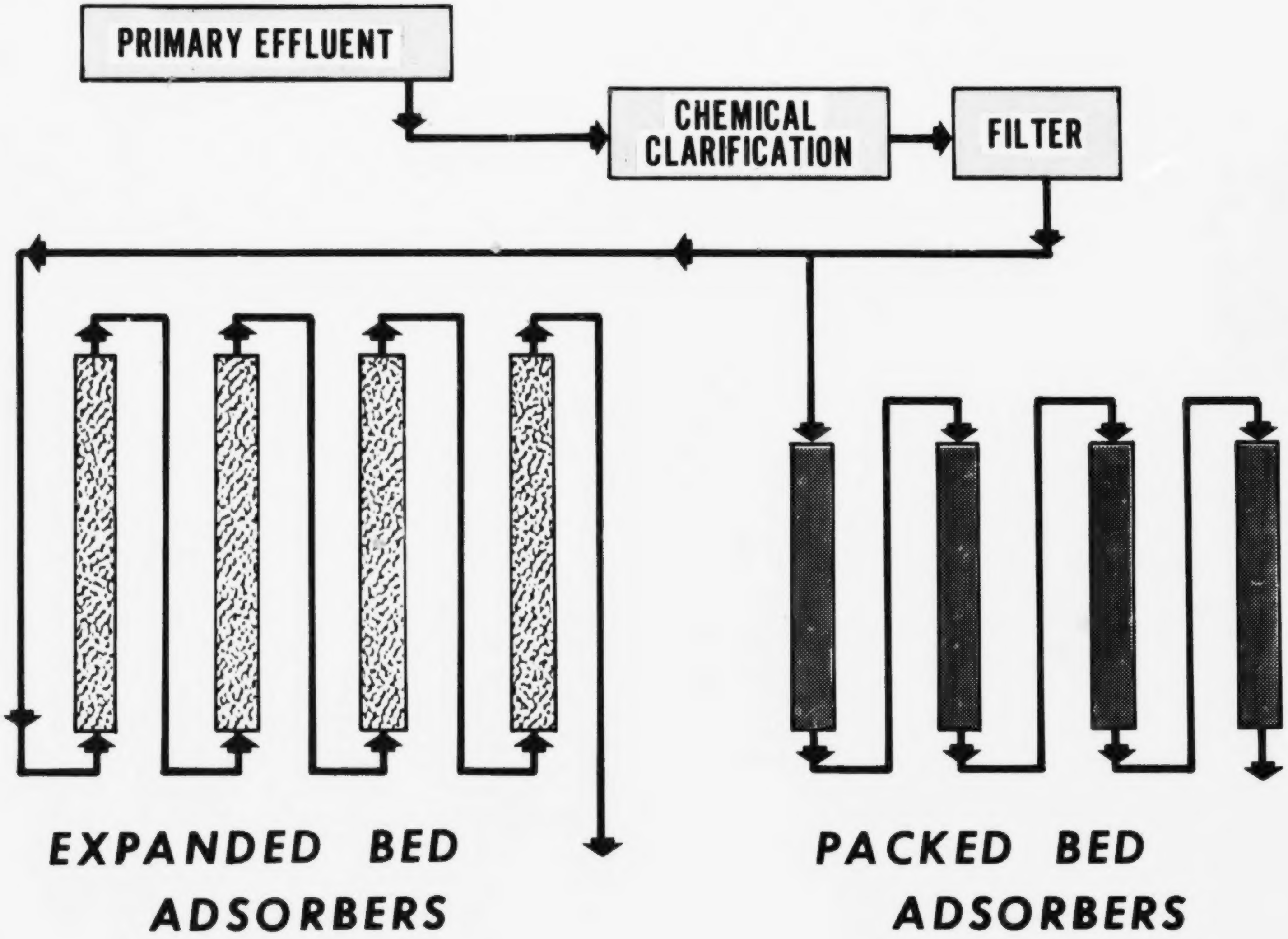


Figure 3. EXPERIMENTAL SET-UP FOR 24 FT. CARBON BEDS

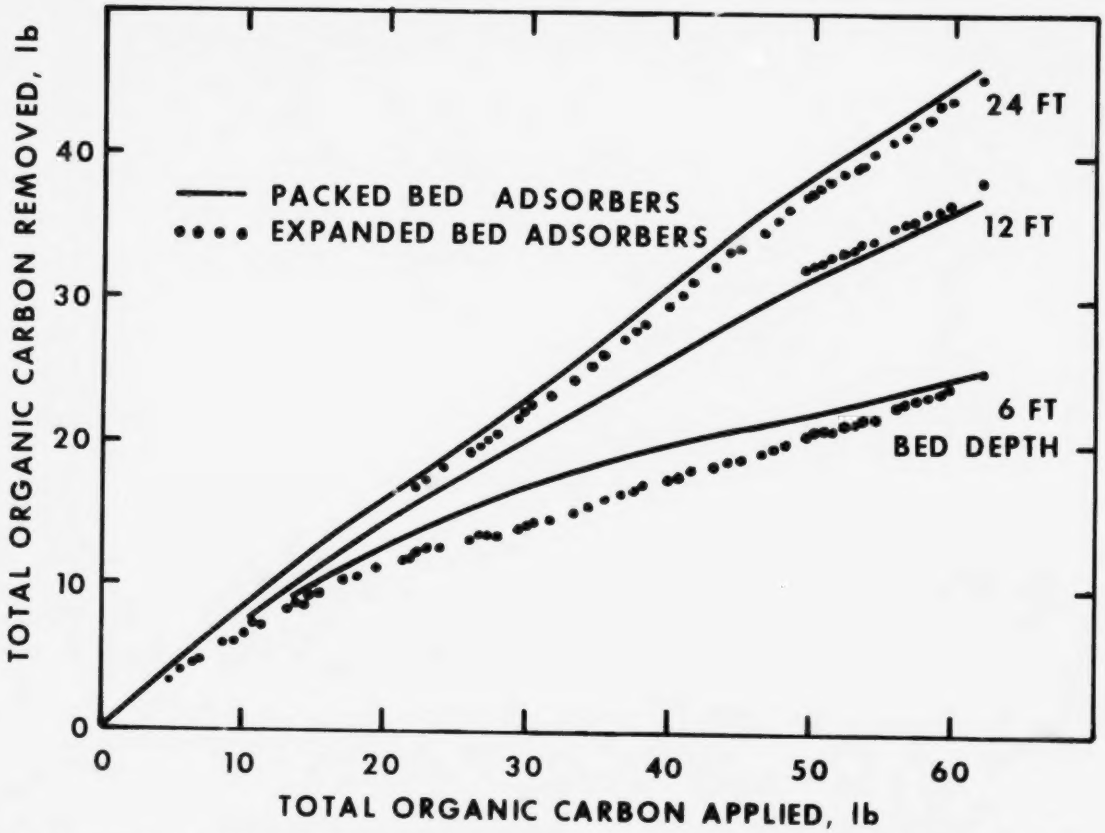


Figure 4. CUMULATIVE SORPTION OF TOTAL ORGANIC CARBON FOR PACKED -BED AND EXPANDED -BED ADSORBERS AS A FUNCTION OF TOC APPLIED. (Lb × 0.454=kg; ft × 0.3=m.)

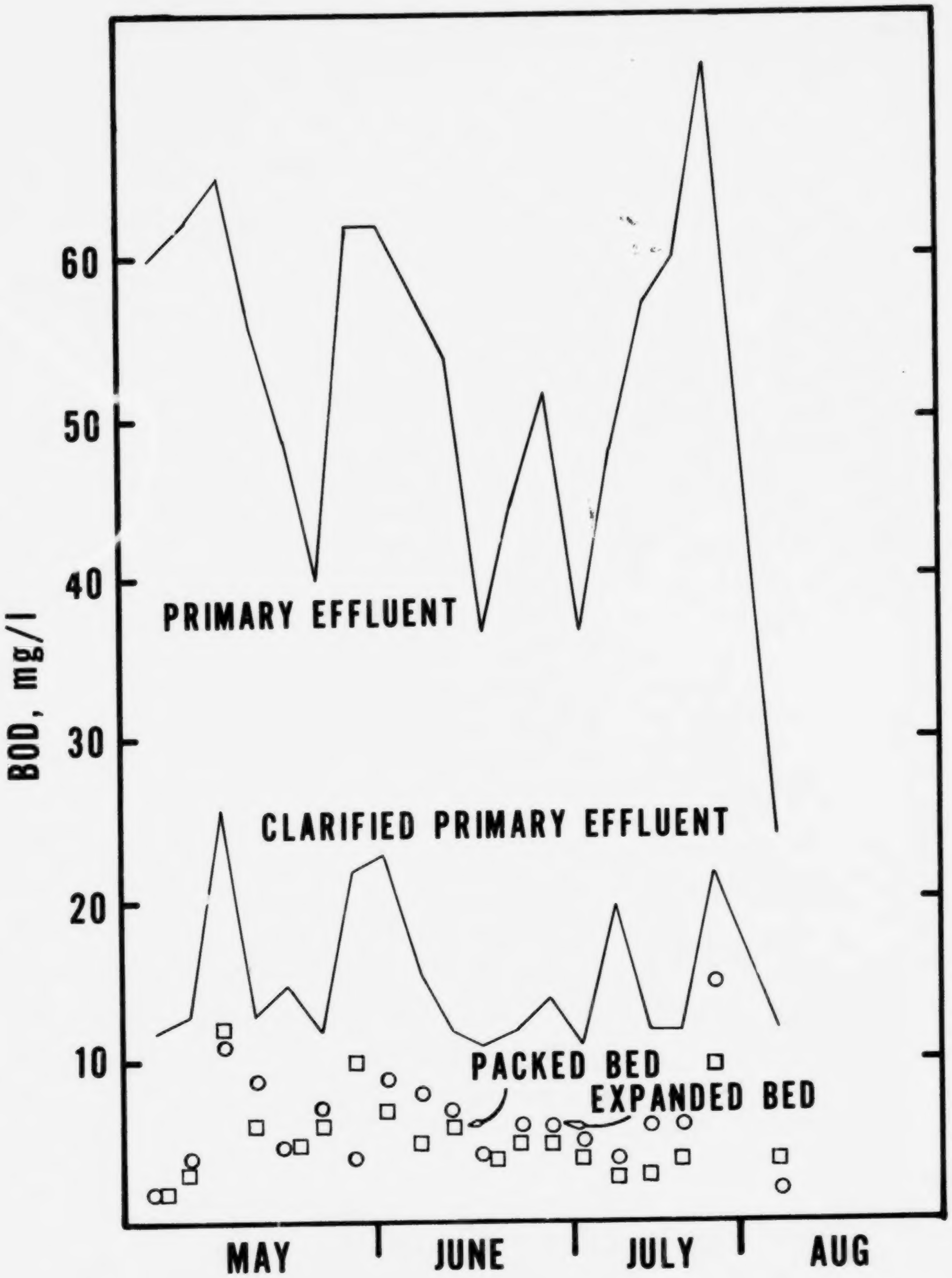


Figure 5. REMOVAL OF BOD BY CHEMICAL CLARIFICATION AND ACTIVATED CARBON

Blue Plains (7)

At the Blue Plains treatment plant in Washington, D.C., a pilot physical-chemical treatment system is being operated as part of a joint effort of EPA and the District of Columbia. Figure 6 is a schematic of the treatment system. Two-stage high lime clarification is provided with a small dose of ferric chloride in the second stage for flocculation of calcium carbonate. This stage of the plant has a capacity of 100,000 gal/day. The filtration, ion exchange and downflow two-stage carbon beds have a capacity of 50,000 gal/day. This plant is highly automated and thus runs with a miniumum of manual control. For example, the lime dose is automatically set by monitoring the pH and alkalinity in the clarifiers, and backwash of the filters, ion exchange columns, and carbon columns is automatically initiated by pressure drop and/or a time cycle.

Figure 7 illustrates the treatment performance obtained at this plant for a variety of pollution control parameters. Nitrogen removal was obtained by the use of an ion exchange process with a zeolite which has a high affinity for ammonium ion. Again, these data indicate that the bulk of the work is done by the clarification step with the filter and carbon columns serving as polishing devices. Table 6 gives the average effluent characteristics for this installation. This effluent is far better in quality than normal secondary effluent.

Salt Lake City, Utah (8)

Under contract between EPA and Eimco Corporation an evaluation is being conducted of a physical-chemical treatment system employing powdered carbon contact after chemical clarification. Figure 8 illustrates the pilot plant. Two countercurrent stages of carbon contact in Reactor-Clarifier are provided following chemical clarification. Some results with lime as the coagulant are given in Table 7. These results are not quite as good as in the plants using granular carbon discussed previously. The effluent, however, must still be classified as of good quality. One potential advantage of this contacting system is the ability to pace the carbon dose to the organic demand. Evaluation of powdered carbon regeneration will take place at this installation. The spent carbon will be dewatered on a vacuum filter prior to being fed to the fluid bed furnace.

Rocky River, Ohio (3)

Several studies have been made utilizing polymer addition to existing primary plants followed by small-scale pilot carbon adsorption. One such study was done at the 10 MGD primary facility at Rocky River, Ohio. An anionic polymer was added to the existing primary clarifier at a dosage of 0.3 mg/l, and a

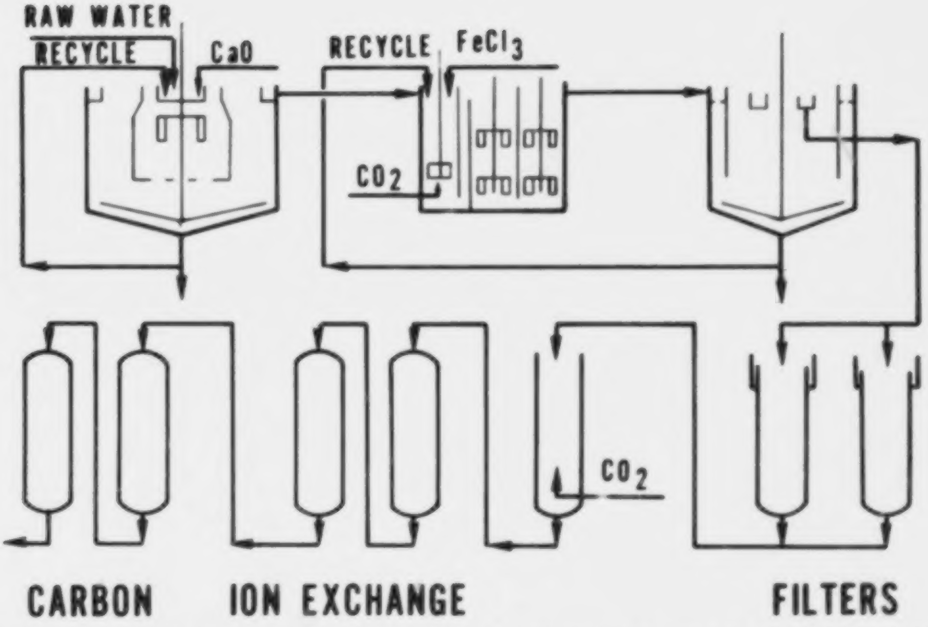


Figure 6. INDEPENDENT PHYSICAL CHEMICAL TREATMENT LIME PRECIPATION

Table 6. EFFLUENT QUALITY P-C PILOT PLANT AT BLUE PLAINS

TOC	6mg/l
BOD	5mg/l
COD	13mg/l
SS	5mg/l
TOTAL P	0.15mg/l
TOTAL N	4.6mg/l

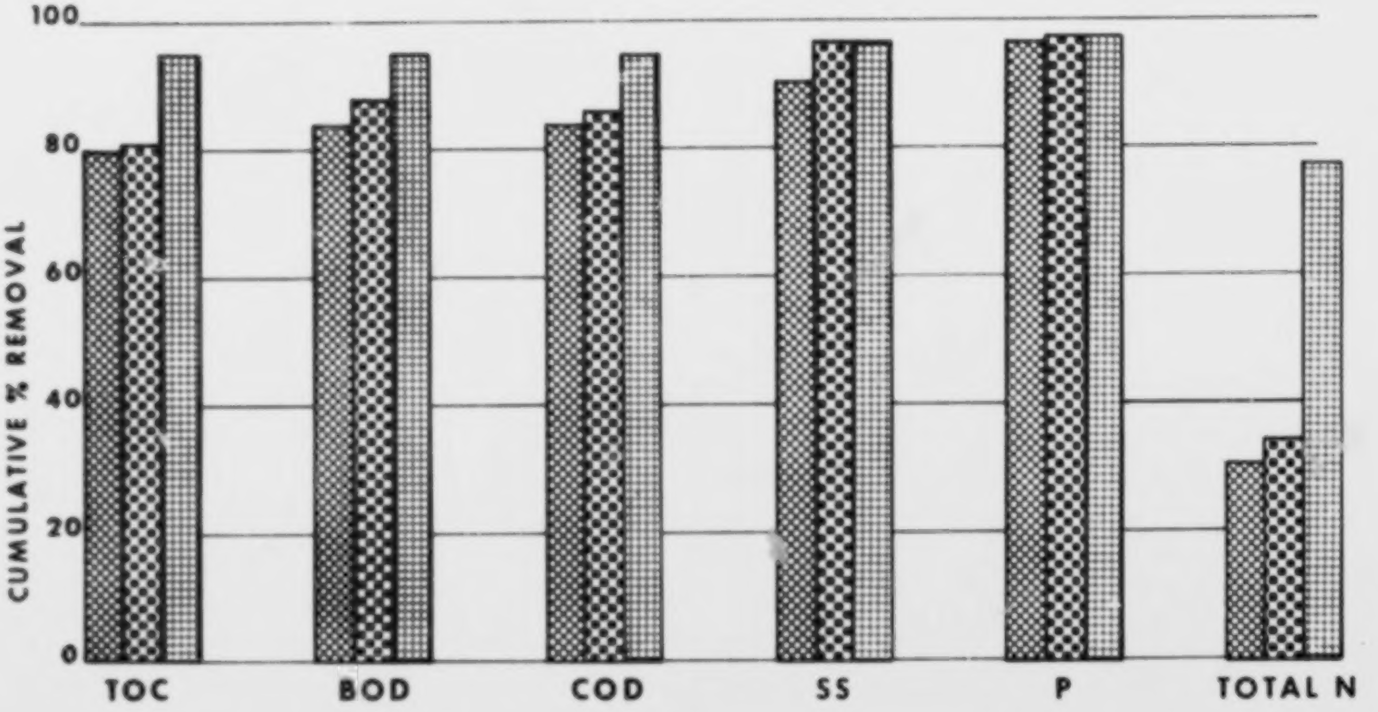


Figure 7. REMOVAL EFFICIENCIES
PHYSICAL-CHEMICAL TREATMENT
BLUE PLAINS PILOT PLANT

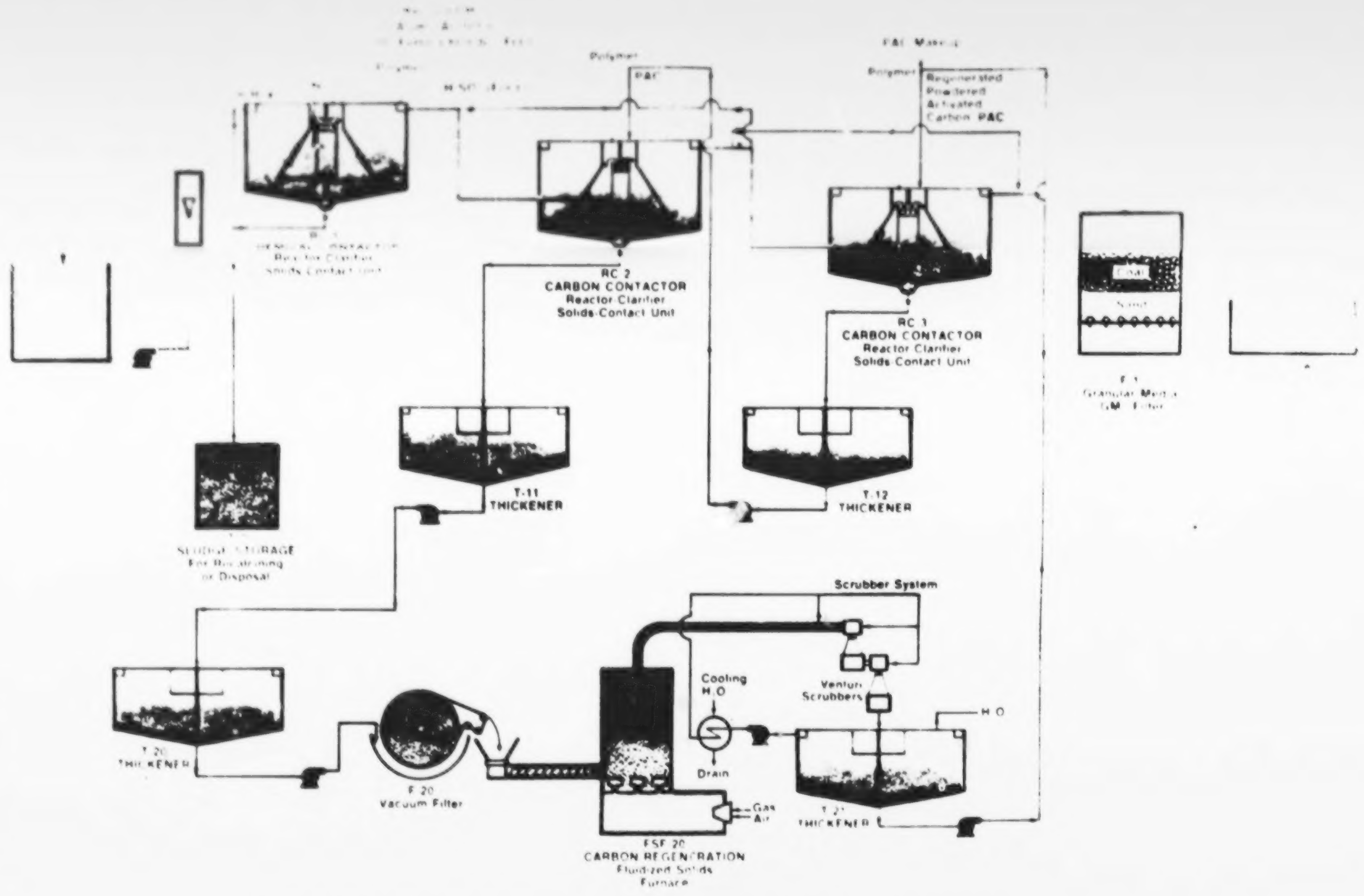


FIGURE 8.PHYSICAL/CHEMICAL TREATMENT PROCESS

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side stream of clarified effluent was applied to small carbon columns for a period of about one month. The summary of the data is shown in Table 8. It can be seen that, even with less than optimum clarification, effluent comparable to good secondary effluent was produced with 33 minutes carbon contact time. On the basis of this preliminary work the City of Rocky River applied for and was awarded a Research and Development Grant from EPA to help support a full-scale investigation of the clarification-adsorption process for secondary treatment.

One of the principal motivations for the city to use physical-chemical treatment is shown in Figure 9. The installation of conventional activated sludge facilities would necessitate the condemnation of a considerable area of expensive property, whereas a carbon adsorption system could easily fit into the existing site. Testing has been undertaken to determine what coagulant or combination of chemicals will be used in the clarification system. If phosphorus removal is required an inorganic coagulant will necessarily be the choice.

ADVANTAGES OF PHYSICAL-CHEMICAL TREATMENT VS. CONVENTIONAL TREATMENT

Several times in this discussion advantages of physical-chemical treatment have been referred to. Perhaps the most important is the stability of operation provided by a treatment system based on physical and chemical technology. Biological systems are notoriously sensitive to changes in environmental conditions. If a toxic material gains even temporary entrance to the plant or a hydraulic peak occurs not only will the efficacy of the biological plant drop off but recovery may take several days to several weeks. In a physical-chemical plant the filtration system backs up the clarifier and the carbon system backs up the first two thus upsets should be unlikely. In addition, it can be expected that an immediate recovery of the plant will take place once the source of upset is eliminated. This inherent stability of performance is also reflected in greater design and operational flexibility. Whole sections of a physical-chemical plant can be cut in or out of the process stream as required, and a temporary overload can be absorbed with little effect. A list of many of the major advantages of a physical-chemical system is given in Table 9. Most have been discussed at some point in this paper.

COST ESTIMATES

Smith (11) has taken the available information from pilot plants and preliminary designs of several proposed large-scale plants and has made cost estimates for various

Table 7.

POWDERED CARBON PILOT PLANT OPERATING CONDITIONS

FLOW RATE 50 GAL/MIN

CHEMICAL 425 mg/l LIME TO pH 10.8

CARBON 150 mg/l + 0.4 mg/l polymer

RESULTS

	COD	BOD	SS	P
RAW SEWAGE	222	144	200	7.3
CLARIFIED EFFLUENT	65	47	28	1.4
FINAL EFFLUENT	35	13	7	0.4

ALL RESULTS GIVEN IN mg/l

Table 8.

ROCKY RIVER WASTE TREATMENT PLANT CLARIFICATION-CARBON PROCESS

	RAW	POLYMER CLARIFICATION	CARBON CONTACT TIME, MINUTES			PERCENT REMOVED
			14	23.4	32.6	
SUSPENDED SOLIDS , mg/l	107	65	13	15	7	93.3
BOD, mg/l	118	57	21	11	8	93.3
COD, mg/l	235	177	67	50	44	81.3

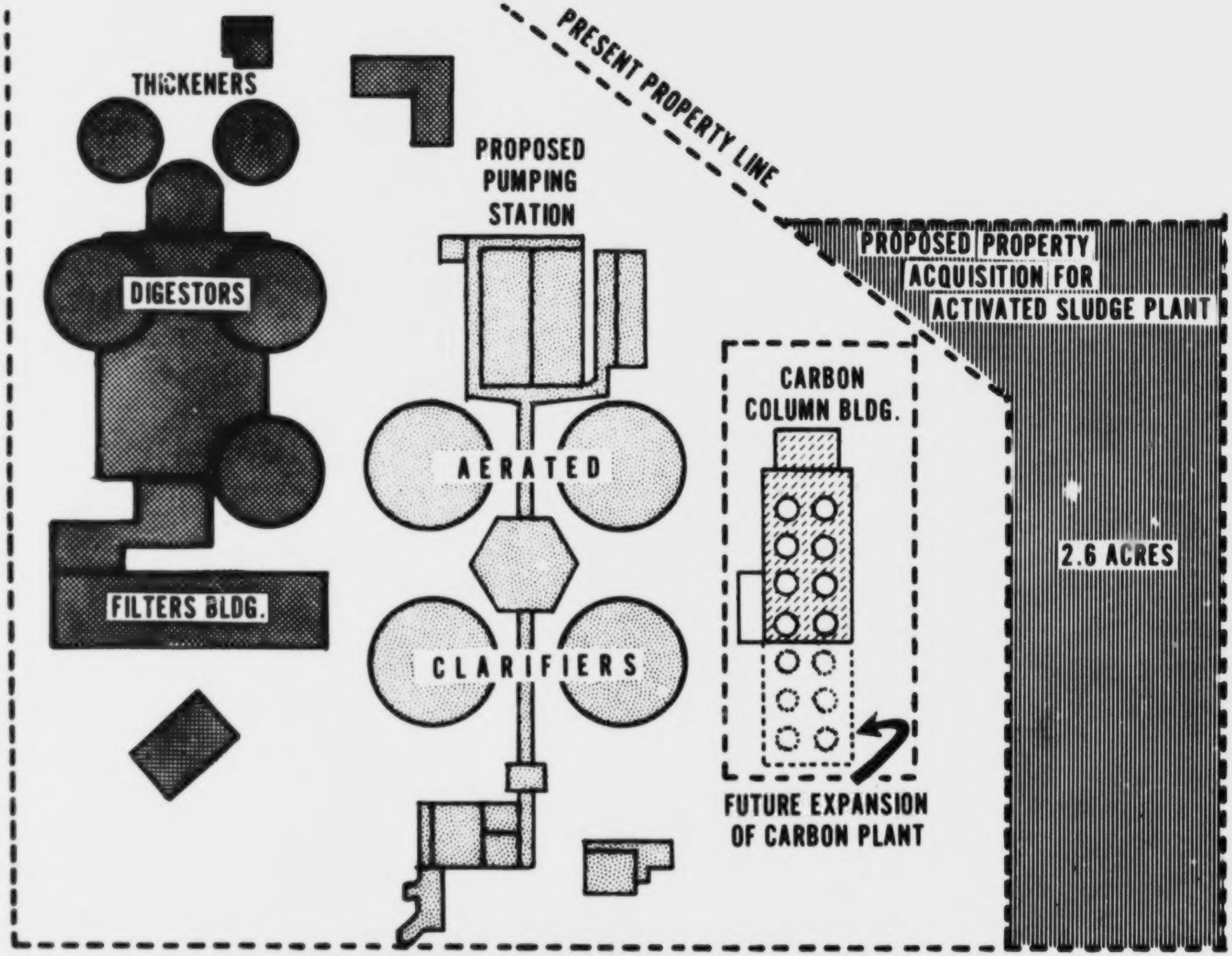

Figure 9. AREA COMPARISON FOR CLARIFICATION-CARBON vs. ACTIVATED SLUDGE PLANTS AT ROCKY RIVER

Table 9. ADVANTAGES OF PHYSICAL-CHEMICAL TREATMENT vs. CONVENTIONAL PRIMARY + SECONDARY

1. *LESS AREA REQUIREMENT-½ TO ¼*
2. *LOWER SENSITIVITY TO DIURNAL VARIATION*
3. *NOT AFFECTED BY TOXIC SUBSTANCES*
4. *POTENTIAL FOR SIGNIFICANT HEAVY METAL REMOVAL*
5. *SUPERIOR REMOVAL OF P COMPOUNDS*
6. *GREATER FLEXIBILITY IN DESIGN AND OPERATION*
7. *SUPERIOR ORGANIC REMOVAL*

size plants referenced to October 1970. Amortization was 6 percent for 24 years. These are presented in Table 10. Note that ranges are given for each plant size. These ranges represent the spread of data available. As a comparison Smith's estimate for primary and secondary treatment with sludge incineration is 16.5 cents per 1000 gallons at the 10 MGD level. With the addition of single stage lime for phosphorus removal the cost would rise to 23.5 cents per 1000 gallons which is essentially the same as physical-chemical treatment.

FUTURE DEVELOPMENTS

As a result of the advantages of physical-chemical treatment discussed above and the favorable economic comparison, a number of full-scale treatment plants are being planned or designed. These are listed in Table 11. Only the first two, Rocky River and Painesville, Ohio, will receive Federal research funds. All the others are being planned with no expectation of Federal funds other than the normal construction grant.

Table 10.

PRELIMINARY COST ESTIMATE
PHYSICAL-CHEMICAL TREATMENT

Total Amortization + O&M, cents per 1000 gallons

Plant Size, MGD	5	10	100
Chemical Clarification*	9.5-13.5	7.3-9.6	4.0-5.3
Carbon Adsorption	11.5-18.0	9.1-13.5	4.5-7.8
Filtration	2.9-4.5	2.1-3.3	1.0-1.4
TOTAL	23.9-36.0	18.5-26.4	9.5-14.5

* Two-stage lime recalcination of sludge.

Table 11. PHYSICAL-CHEMICAL TREATMENT PLANTS

SITE	CAPACITY	STATUS
ROCKY RIVER, OHIO	10	BIDS TAKEN
PAINESVILLE, OHIO	5	DESIGN
CLEVELAND, OHIO	10	DESIGN
FITCHBURG, MASSACHUSETTS	15	DESIGN
WATERFORD, NEW YORK	2	PLANNED
CORTLAND, NEW YORK	10	PLANNED
CLAY, NEW YORK	10	PLANNED
NIAGARA FALLS, NEW YORK	60	PLANNED
GARLAND, TEXAS	30	DESIGN
OWOSSO, MICHIGAN	6	DESIGN

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UPGRADING EXISTING WASTEWATER TREATMENT PLANTS

Second U.S. - Japan Conference on
Sewage Treatment Technology

National Environmental Research Center-Cincinnati
Advanced Waste Treatment Research Laboratory

Cincinnati, Ohio
December 1, 1972

R. L. Bunch
Chief, Biological Treatment Research Program

UPGRADING EXISTING WASTEWATER TREATMENT PLANTS

R. L. Bunch

I. INTRODUCTION

It is an established fact that many biological wastewater treatment plants produce a poor quality effluent. Often, the treatment process itself is mistakenly cited as being inadequate, whereas the true fault lies in not applying known principles and technology efficiently. A properly designed and well-operated activated sludge plant needs no new technology to achieve 90 - 95 percent carbon, suspended solids and coliform removals. What is needed is an awareness of the fundamentals involved and a willingness to pay for and apply all we know.

Many secondary treatment plants in this country are now operating near or over the design capacity. Construction of all new plants cannot be undertaken immediately. In the meantime, what can be done to upgrade the existing plants? When plans are made for new treatment plants, what considerations should be made for future treatment processes?

The object of this talk is to present several general ways of achieving higher removals so that you can carry them back with you and apply them wherever applicable.

II. PROPER PLANT OPERATION

There are three main reasons why there are so many poorly operated treatment plants.

A. The first reason is that many smaller cities fail to realize the necessity of providing a competent and industrious plant operator to perform certain fundamental duties at the right time and in the right way. A plant will not run itself. The difference between a poor and a good operator can often mean 25 - 30 percent differences in overall effectiveness. No matter how much research we do, or what new designs capable engineers develop, little improvement will be made without competent operators. Figure 1 shows the type of operator training required. Seventeen (17) states have a mandatory certification requirement, 28 have a voluntary requirement and only 5 have no program.

B. The second reason why there are so many poorly operated treatment plants is that many city officials fail to provide yearly a sufficient repair and replacement fund. Continuing good operation is not possible when equipment is constantly down for repairs or because it is antiquated. The municipal treatment plants of today are highly mechanized and represent a heavy investment of public funds. Funds should be provided for a scheduled maintenance program.

C. The third reason is the lack of laboratory facilities and the staff to make the necessary analyses. It is unfortunate that in the past, designing engineers did not provide space for routine tests. Without certain analytical determination a treatment cannot be run intelligently. In addition to given guidance to the operator, well-documented records will serve as valuable reference information when plant expansion is planned. Almost every municipality will sooner or later have to extend or rebuild its present treatment plant.

III. AIDING OVERLOADED PLANTS

Over 94 percent of the existing treatment plants in the United States have capacities of less than 5 mgd. Past experience has indicated that plants smaller than 5 mgd have a higher proportion of operational problems than do plants of larger size. The suggested upgrading procedures are aimed at this size plant.

If there are no unusual toxic or atypical wastes present, the poor performance of a plant can be traced to one or more of these factors: hydraulic overload, organic overload, or poor final clarifier liquid-solids separation.

A. Hydraulic Overload

1. Find and reduce needless sources.

The first place to look is for groundwater infiltration. The majority of sewers are constructed below the prevailing groundwater tables and therefore subject to infiltration. In the United States, infiltration flow average 15 percent of the total sewage flow and during prolonged rainy periods it can amount to 30 percent of the total flow. The principle causes of infiltration are defective pipe, faulty pipe joints, and poor manhole construction. Extraneous surface water from roof, cellar and foundation drains and other illegal connections can add an additional 20 percent to the flow.

Industrial cooling water can be another source. Cooling water should not be put into the sanitary sewer system. The operator of the Bryan, Ohio, plant was able to reduce his hydraulic load by having the metal plating shops and food processors reduce rinsing operation.

2. Equalization Tank

The rate of flow of wastewater from any district varies with the season, the day, and even the hour. These hourly, daily, and seasonal fluctuations of flow affect the operation of the treatment plant. If a plant is hydraulically overloaded, an equalizing or surge tank will smooth out the high peak flows. This tank should be aerated and not be considered a settling basin. An equalization tank offers the following advantages:

a. Hydraulic surges eliminated
b. Biologic load fluctuations lessened
c. Toxic wastes mixed and diluted
d. Better downstream settling
e. Constant flow for tertiary treatments
f. Lessens raw sewage discharge during rain storms

3. Consider Using Large Interceptors as Holding Tanks

Very large long interceptor sewers can serve as holding tanks during the peak flows and then the backup processed through the plant during the low night time flows.

4. Improve Solids Separation

Hydraulic overloading tends to sweep the solids past the final discharge. These suspended solids are largely organic in nature; therefore, BOD reductions will parallel solids reduction. Retaining these solids can improve your plant while planning, funding and constructing new facilities. Several methods for improving solids removal are:

a. Increase sedimentation tank capacity
b. Chemical precipitation or flocculation
c. Separation by microscreening
d. Rapid sand filters
e. Flotation

B. Organic Overload

1. Have industry program load.

Industries in smaller towns are usually willing to program their strong waste discharge to coincide with lower loading periods of the day.

2. Equalization tank to smooth load.

A surge tank is useful in diluting strong wastes and evening out the load to the secondary system.

3. Chemical precipitation or flocculation or raw sewage.

By removing a larger portion of the BOD and suspended solids in the primary clarification unit, the organic loading on the secondary process is greatly reduced. Chemicals commonly used are the iron compounds, alum, lime and synthetic organic polyelectrolytes.

4. Roughing trickling filter.

The recently developed plastic trickling filter media have a good potential for reducing the incoming organic load when used ahead of the normal secondary process. If used only to control organic overloads, a roughing filter does not require a separate settler.

5. Increase MLVSS and air supply.

6. Baffle aeration tank to stop short-circuiting.

The older designed spiral-flow aeration tanks tend to have a center core that does not get mixed resulting in short-circuiting of a portion of the flow.

7. Eliminate digester supernatant or at least program load.

The digester supernatant is normally recycled to the influent line of the waste treatment plant. The COD and ammonia concentration of 10,000 and 1,000 mg/l, respectively, are common and constitute a tremendously high oxygen demand. The digester supernatant should be treated separately or returned slowly to the plant at low load times. Too often the supernatant is returned in a slug during the day. This can cause an upset to the plant.

8. AWT treats part of the final effluent and blends.

Various advanced waste treatment processes can be applied to a portion of the final effluent, and this blended with the total flow to meet new water quality standards. This could be by chemical addition, carbon adsorption, filtration, etc.

IV. FUTURE DESIGN CONSIDERATIONS

A. Laboratory Control Space

Today, it is well-known that the lack of proper laboratory controls will adversely affect the performance of any treatment plant, large or small. More and more installations are using the fundamental principles of hydraulics, bacteriology, and chemistry in their operations.

B. Emergency Power Facilities

A standby power source should be provided so that raw sewage is not discharged or let backup in sewers until they overflow.

C. Automatic Control Equipment

The trend of sewage treatment processes is toward mechanization and automatic controls. These developments are becoming increasingly necessary, not only as a means of increasing the ease and efficiency of treatment, but also because the increasing difficulties experienced in obtaining labor for the more unpleasant and laborious duties in waste treatment.

D. Chemical Storage

Consideration should be given to providing a space for a future building to house chemicals. AWT treatment considered today, requires storage and handling of truckloads of precipitating agents, coagulants, and activated carbon.

E. Chemical Feeding

Improve degree of treatment required in the future will undoubtedly make use of chemical methods. Provision should be made in the plant layout so that much expense is saved in future extension.

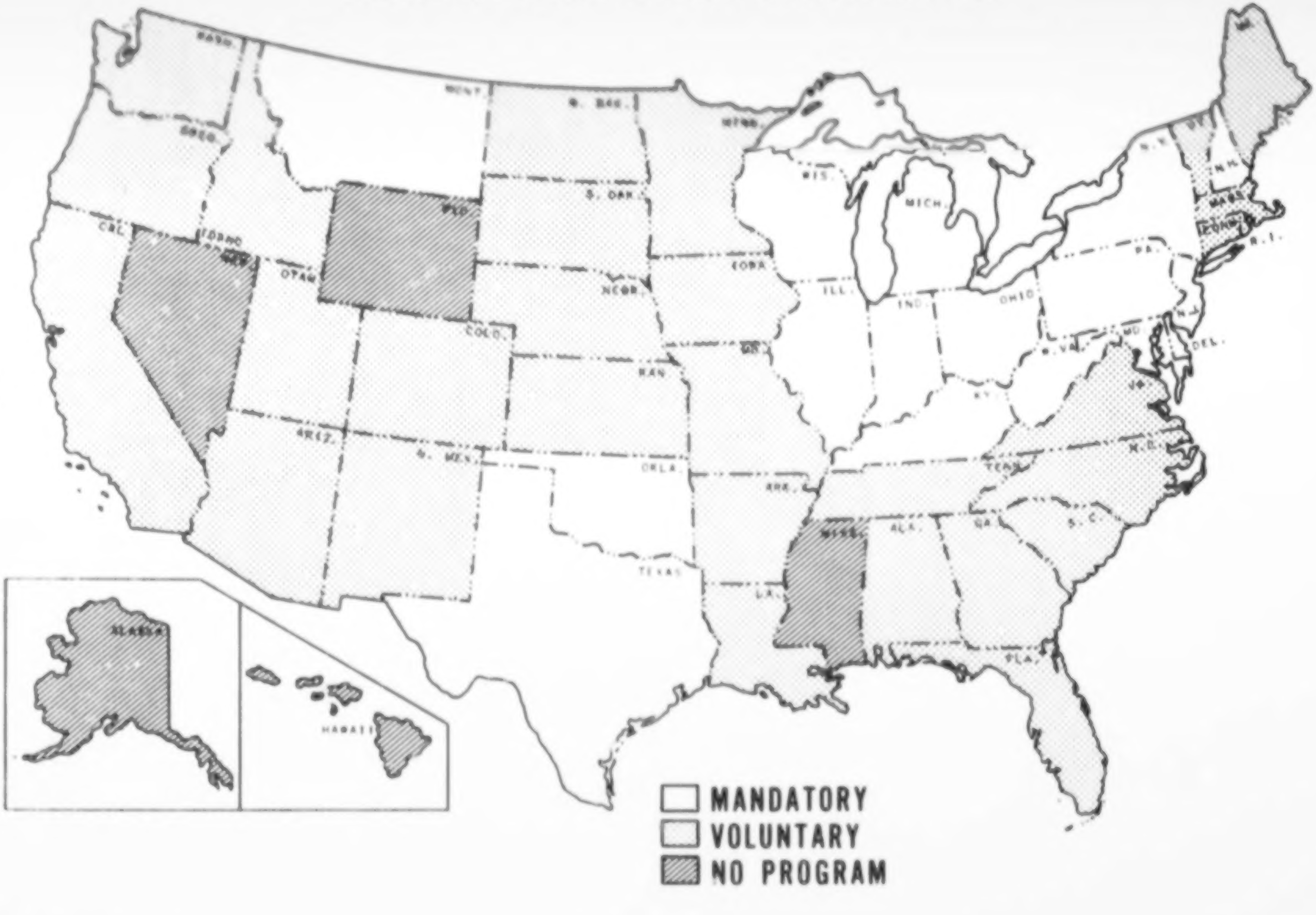
F. Factor of Treatability

In the early days of waste treatment, plants were designed to deal primarily with domestic sewage. Experience with domestic sewage has dictated the design criteria in the past, but many industrial organic wastes do not have the same degree of amenability. The frequency with which difficulties appear is increasing. Some industrial effluents are not readily amenable to biological treatment and specially designed processes will have to be used to deal with the more biologically-resistant materials. In many cases, it will be necessary in increase detention times to assure 95 percent removal.

A further aspect of the problem of treatability occurs with sludge digestion. Any toxic material which separates with the sludge might affect the sludge digestion process. There appears to be a growing awareness in this country of digester troubles without an equal cognizance of the causes of the troubles.

For unknown wastes, the degree of amenability must be established before adequate design can be developed. Properly designed processes can make some undesirable wastes more amenable to biological treatment. Some wastes will cost less to treat if done separately at their origin while they are in a concentrated form. The difficult cases to decide are the ones where the wastes are not completely inhibitory to the treatment process. In this case, they interfere with the treatment process to the extent that the effluent quality is lowered and the capacity of the plant must be increased to accommodate them.

FIGURE 1
TREATMENT PLANT OPERATOR CERTIFICATION



SUMMARY DESCRIPTION OF OXYGEN AERATION SYSTEMS IN THE UNITED STATES

Second U.S. - Japan Conference on
Sewage Treatment Technology

National Environmental Research Center-Cincinnati
Advanced Waste Treatment Research Laboratory

Cincinnati, Ohio
December 1, 1972

Richard C. Brenner
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SUMMARY DESCRIPTION OF OXYGEN AERATION SYSTEMS IN THE UNITED STATES

Richard C. Brenner

BACKGROUND

The use of oxygen for aeration in activated sludge treatment became a subject of more than academic interest in 1968 with the awarding of a full-scale research and development government contract to the Linde Division of the Union Carbide Corporation to evaluate a proprietary oxygen aeration process at the Batavia, New York Municipal Wastewater Treatment Plant (See Figure 1). Since then, a great deal of extramural and in-house effort has been expended by the Environmental Protection Agency in both fundamental research and process development. At this time, the oxygen aeration process stands on the threshold of widespread acceptance and utilization by the municipal and industrial waste treatment fields.

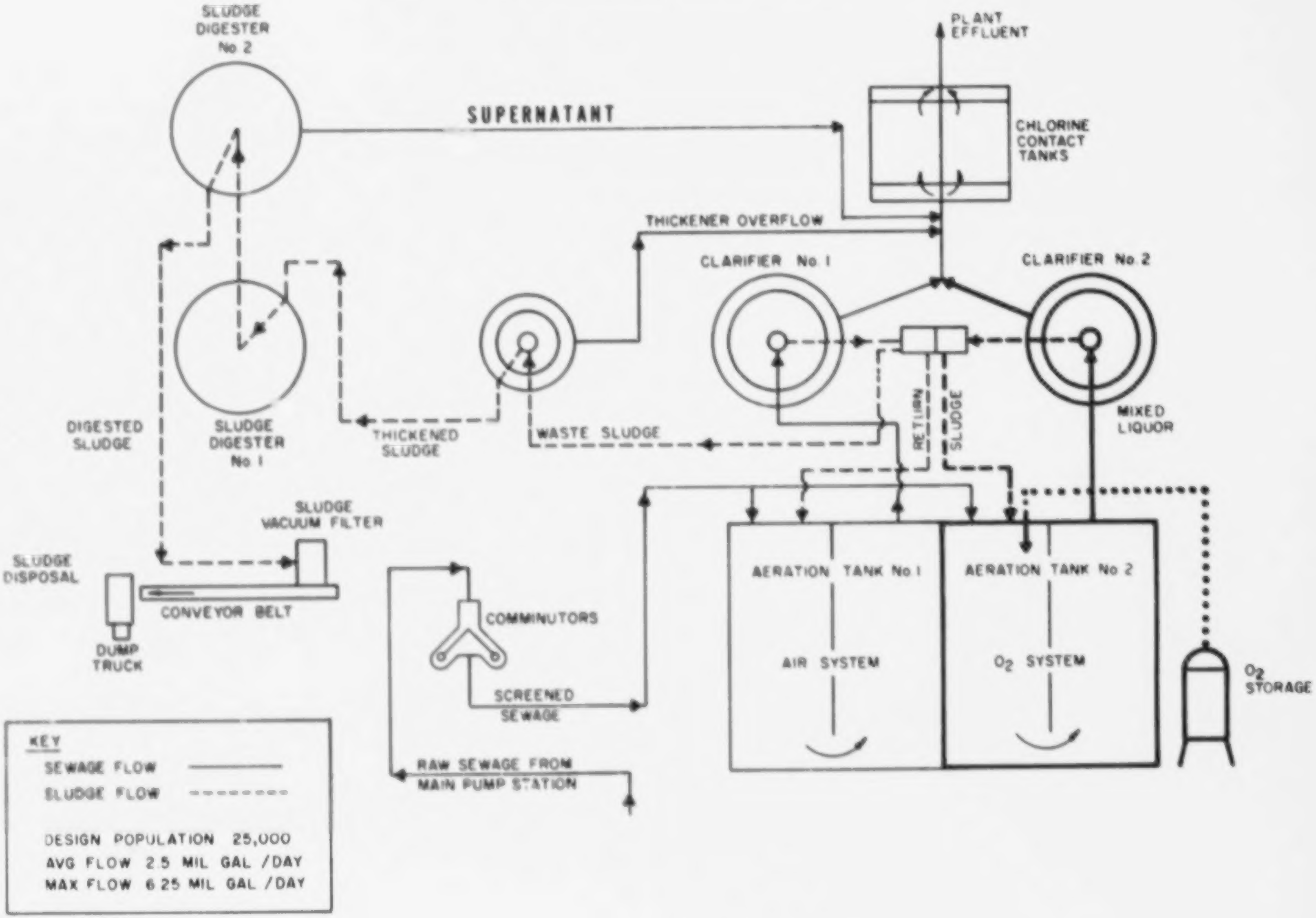
The rationale for substituting oxygen for air in biological treatment is to increase the available driving force for dissolving oxygen in wastewater, thereby removing dissolved oxygen from the role of rate limiting factor in microbiological reactions. The development of cost effective oxygen aeration systems by several firms offers potential for exploiting the obvious process advantages of oxygen aeration and for yielding savings in total treatment costs. For new plants, these savings will consist mainly of reduced reactor tank volumes, reduced aeration energy and power requirements, and reductions in the amount of waste biological sludge produced. An additional application is the conversion of existing overloaded secondary plants to oxygen use to increase capacity and treatment efficiency with minimum acquisition of land.

LINDE OXYGEN AERATION SYSTEM ("UNOX")

The original Linde oxygen aeration (oxygenation) system, evaluated at Batavia, now marketed under the trade name "UNOX", is designed to function in a conventional plug flow configuration. To prevent excessive loss of oxygen gas to the atmosphere, a gas tight cover is fitted to the top of the aeration tank. Vertical baffles are installed at regular intervals, extending from tank cover to tank bottom, throughout the length

FIGURE 1

WATER POLLUTION CONTROL PLANT, CITY OF BATAVIA, N.Y.
SCHEMATIC FLOW DIAGRAM



of the aerator to form a series of compartments or stages. For new plants, the cover and baffles can be poured integrally with the tank walls and bottom. At an existing plant such as Batavia, the cover and baffles must be added and fitted to existing aeration tank structures.

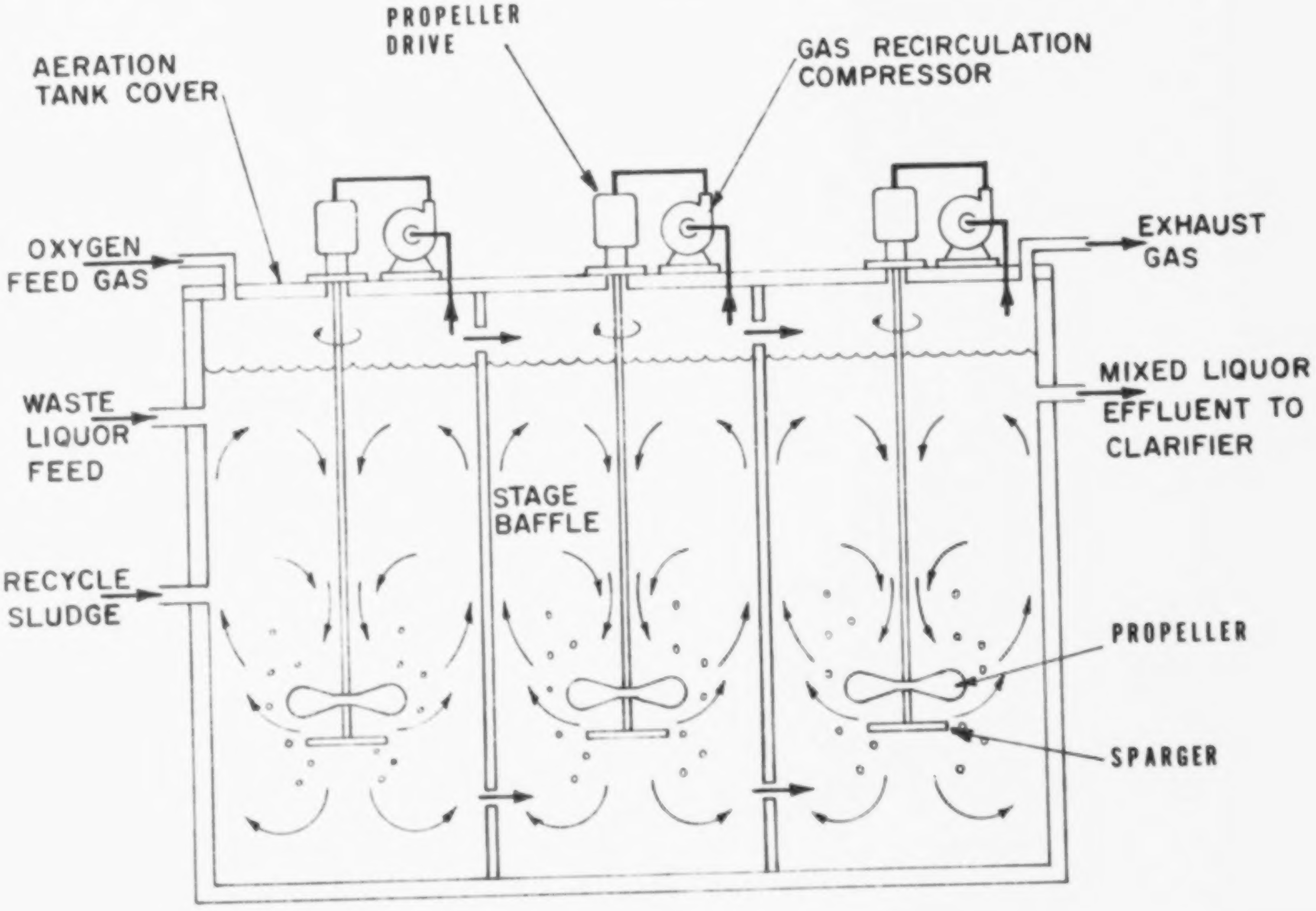
A typical three-stage "UNOX" system, such as installed in each pass of the Batavia oxygenation tank, is shown in Figure 2. Each stage is equipped with a recirculating gas compressor and a rotating submerged propeller-sparger combination. Gas contained in the vapor space is compressed and forced down through the hollow propeller shaft and out through the rotating sparger into the mixed liquor of each stage. In addition to providing the energy to maintain bulk fluid movement, the rotating propellers, located approximately two feet above the spargers, shear the gas bubbles issuing from the apargers into smaller bubbles. The downward circular mixing pattern established by the propellers decreases the net rise rate of the bubbles, thereby creating a longer gas-liquid contact time in each stage before the unassimilated gas vents back into the vapor space. The recirculating gas compressors can be mounted directly on top of the tank cover, similar to Batavia, or to the side of the aeration tank, space permitting.

Oxygen gas is fed into the system at one point only, the lead stage. The inlet gas is 100% oxygen if supplied from liquid storage or by a pressure-swing adsorption molecular sieve generator, the purity drops to about 90%. The rate of oxygen gas feed is controlled by maintaining a positive pressure of 2-3 inches of water column in the vapor space. When the vapor pressure drops below this level indicating an increased oxygen consumption rate, a control valve automatically permits the oxygen feed rate to increase until the desired pressure is re-established. Conversely, the oxygen feed rate is automatically decreased when the vapor pressure rises above the control level.

Gas and liquid proceed from stage to stage in co-current fashion through appropriately sized openings in the vertical baffles. A portion of the unassimilated oxygen gas that vents back into the vapor space of each stage is continuously recompressed and recirculated through the hollow propeller shaft and out the sparger. The remaining gas is

FIGURE 2

SCHEMATIC DIAGRAM OF MULTI-STAGE OXYGENATION SYSTEM



continuously forced through the baffle opening by the 2-3 inch water pressure maintained in the vapor space. In this manner, the vent gas from each stage becomes the feed gas for the succeeding stage.

The vapor space gas becomes increasingly contaminated with gaseous products of decomposition and inert gases in each succeeding stage. By the time the gas flow reaches the last stage, oxygen composition has fallen to approximately 50%. The exhaust gas rate from the last stage to the atmosphere will vary from 10-20% of the incoming oxygen feed rate to the lead stage, which combined with the drop in oxygen composition through the system from 100% to 50% yields an overall oxygen utilization of 90-95%. The positive pressure maintained in the vapor space prevents atmospheric air from backing into the last stage.

Mixed liquor dissolved oxygen is controlled in each stage by the compressor recirculation rate for that stage. In the lead stage where oxygen demand is greatest and dissolved oxygen levels are more likely to fluctuate, it may be necessary to automatically control compressor recirculation rate with a feedback loop tied into a dissolved oxygen sensor. In downstream stages, automatic dissolved oxygen control will normally not be required and recirculation rates can be adjusted by manual valve settings.

The co-current gas and liquid provision contributes to the excellent gas transfer kinetics of the "UNOX" system. By introducing makeup oxygen into the lead stage, maximum driving force for dissolving oxygen coincides with maximum mixed liquor oxygen demand. The subsequent decrease in oxygen composition through the system roughly parallels the drop in mixed liquor oxygen demand. Inasmuch as the partial pressure of pure oxygen gas is almost five times larger than oxygen in air, mixed liquor dissolved oxygen concentrations of 8-10 mg/l can be maintained with relative ease in an oxygenation system.

ALTERNATIVE OXYGEN AERATION SYSTEMS

A number of alternative systems employing oxygen aeration in activated sludge treatment have either been developed or are under development. These systems will provide the design engineer with options to the Union Carbide "UNOX" process.

The first system described briefly herein employs the "SIMPLOX" oxygen aeration process (shown schematically in Figure 3). This process, developed by the Cordon International Corporation (formerly the Cosmodyne Corporation), is another covered tank concept and is intended primarily for upgrading existing air activated sludge plants equipped with centrifugal air compressors and conventional air diffusers. The air compressors are corrosion proofed and modified to be compatible with oxygen service. Oxygen gas is introduced through a sparger to the head of the aeration tank. Undissolved oxygen gas and gaseous by-products venting into aeration tank head space are continuously recycled to the mixed liquor through the modified air compressors and the conventional air diffusers. Exhaust gas is bled from the system at the exit end of the aeration tank. Power required for oxygen dissolution is greater in the "SIMPLOX" process than in the "UNOX" process because: (1) equipment initially designed for transferring oxygen from air in open tanks is used, and (2) the gas phase above the mixed liquor is completely mixed and assumes the same oxygen composition as the exhaust gas stream; thus, the driving force for dissolving oxygen in water is less than in the lead stages of a multistage unit. However, capital costs are considerably reduced with the "SIMPLOX" process inasmuch as the concept does not require vertical staging baffles and new oxygen dissolution equipment.

An Environmental Protection Agency grant has recently been awarded to the Las Virgenes, California Municipal Water District to demonstrate the "SIMPLOX" process at a 1-2 mgd scale (See Figure 4). The major objective of the project is to demonstrate that oxygen aeration can be used successfully to increase the organic loading capacity of existing activated sludge treatment plants with minimum capital expenditure and without unduly increasing the operating costs above those associated with a multi-stage reactor.

A completely different type of oxygen aeration system utilizing a pipeline reactor has been developed by AIRCO (formerly the Air Reduction Company). In this system, a large diameter pipeline (30-36 inches) replaces the traditional aeration tank as the biological reactor as depicted schematically in Figure 5. Wastewater and oxygen gas move

FIGURE 3

SCHEMATIC DIAGRAM OF DIFFUSED AIR AERATION SYSTEM MODIFIED TO RECIRCULATE OXYGEN GAS LAS VIRGENES, CALIFORNIA PROJECT

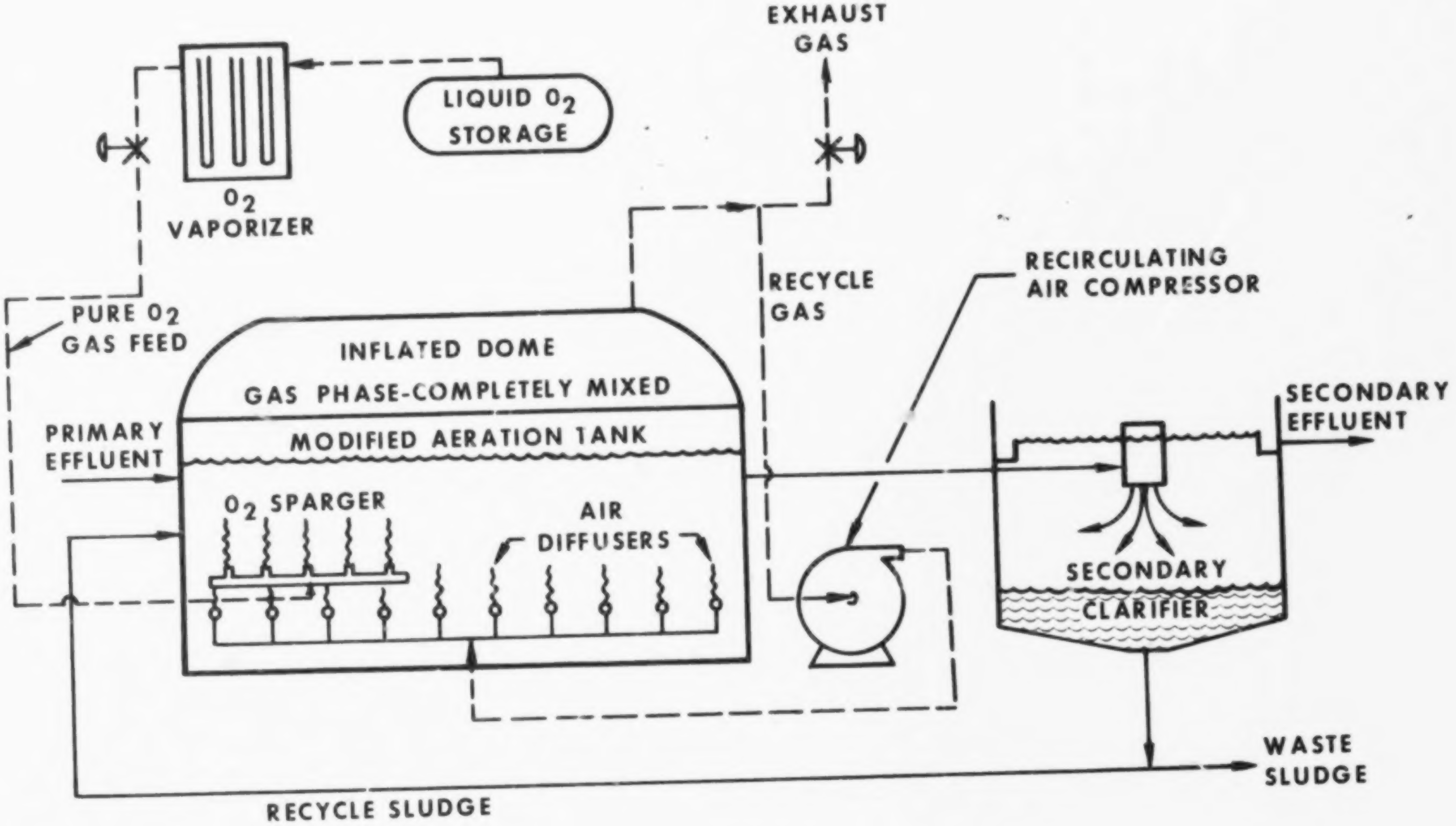


FIGURE 4

FLOW DIAGRAM
LAS VIRGENES OXYGEN SYSTEM

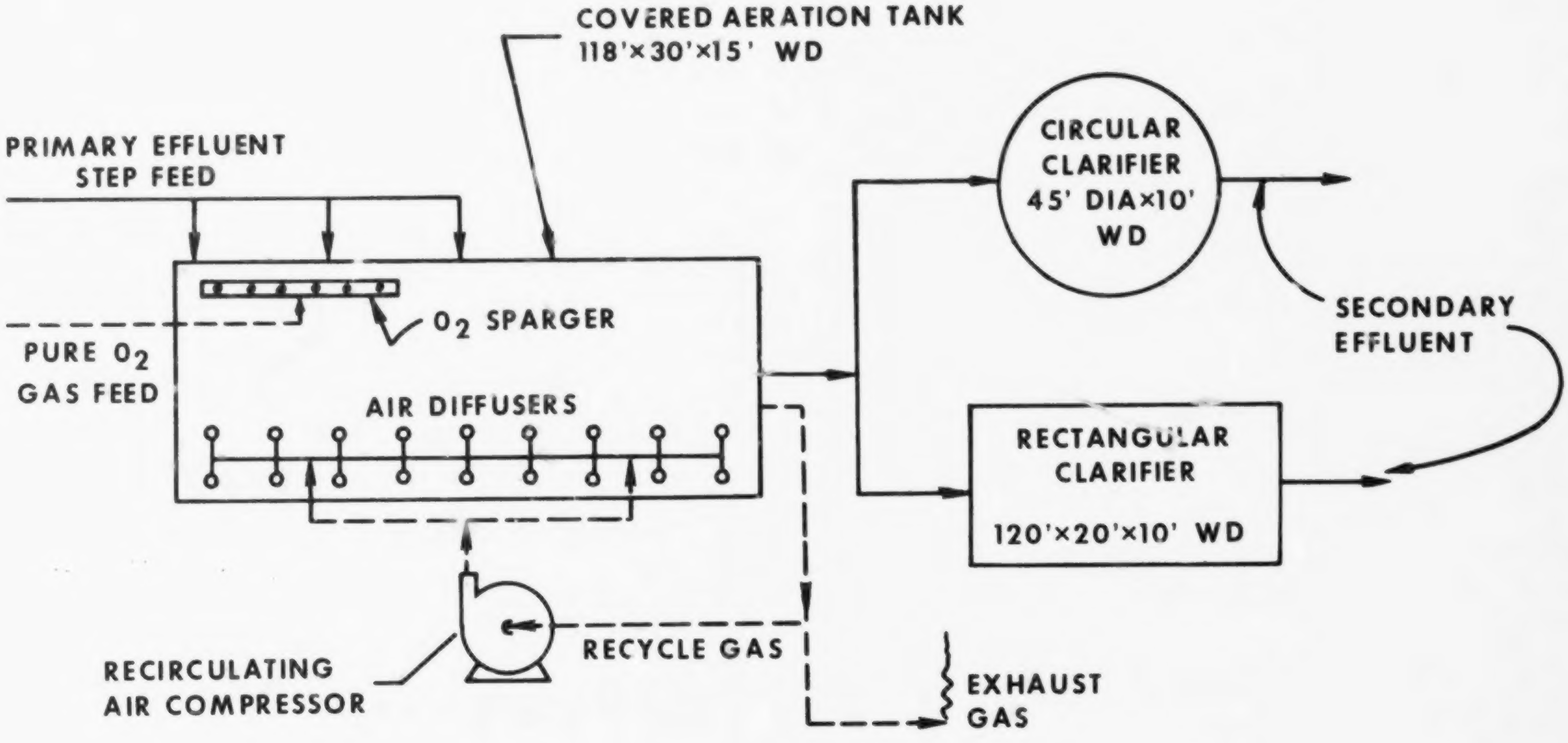
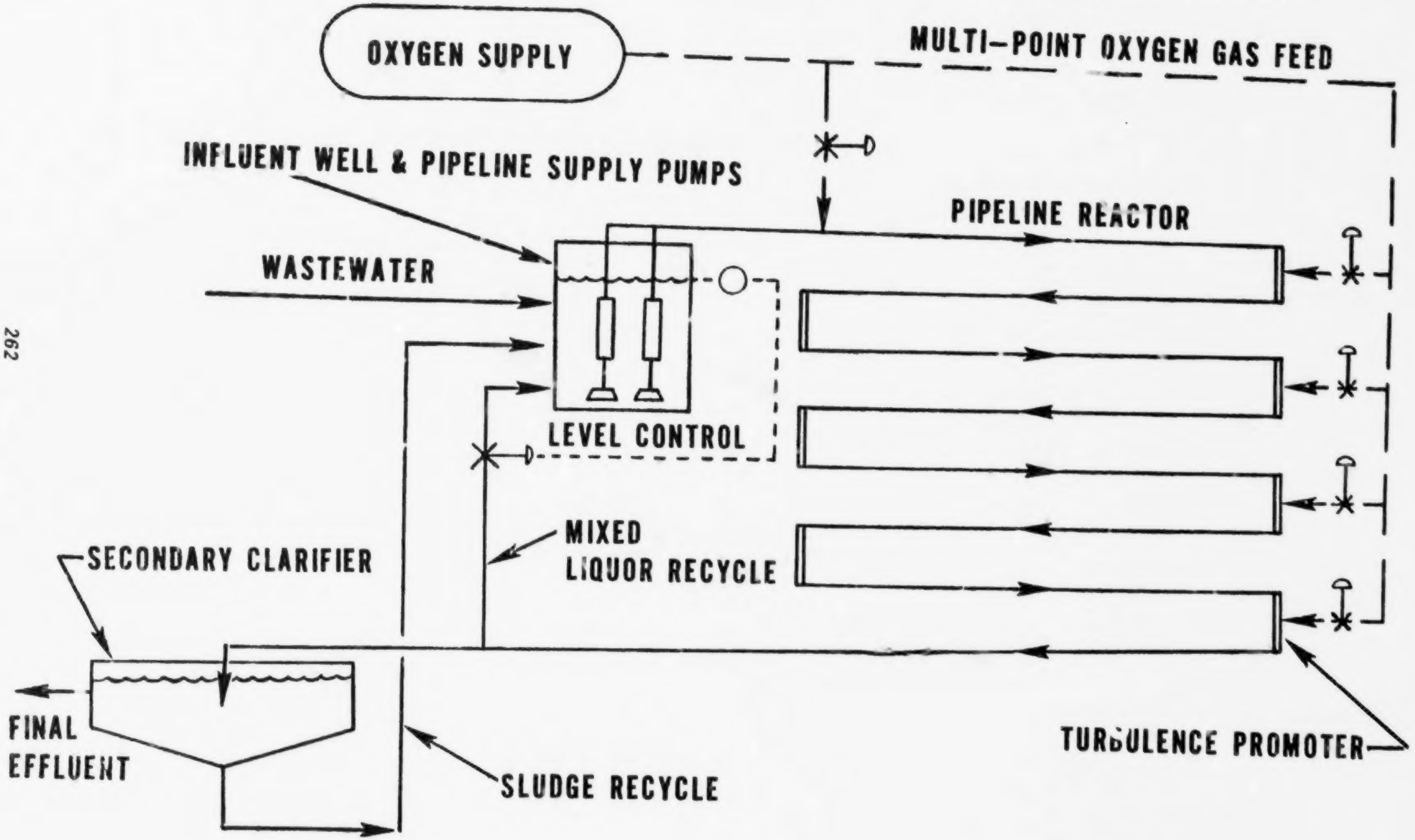


FIGURE 5

SCHEMATIC DIAGRAM OF PIPELINE REACTOR OXYGENATION SYSTEM



forward in unison in ideal or theoretically perfect plug flow. The only moving parts required are the pumps which supply wastewater and recycle sludge to the pipeline. Direct mixed liquor recycle is also used during low flow periods to maintain liquid velocity in the pipeline at a minimum of 1 ft/sec. In large diameter pipes, however, it has been found that velocities of 1-2 ft/sec do not create sufficient turbulence to dissolve any appreciable quantity of oxygen gas in the wastewater stream; the two materials simply flow down the pipe in two distinct phases, the gas on top, with little interaction. AIRCO utilizes artificial turbulence promoters at points of oxygen injection to effect the necessary oxygen transfer (see Figure 6). The essential turbulence can be provided by injecting oxygen gas either into the downward leg of a vertical U-tube or just ahead of a horizontal pipe section fitted with an egg-crate pattern insert. Either method will transfer approximately 20 mg/l of oxygen gas to wastewater with an accompanying 4 ft head loss, provided, of course, that a high purity oxygen source is employed. The turbulence promoters and oxygen injection points are staggered along the pipeline reactor at intervals dictated by oxygen demand.

The pipeline reactor has not been demonstrated other than at pilot scale. The first full-scale (3-4 mgd) system is now being designed by AIRCO for the Passaic County, New Jersey Sewer Authority for installation at Haskell, New Jersey. Nothing further can be reported until this initial installation is completed and begins generating operational data.

A third approach using oxygen instead of air for aeration of activated sludge has been designed and is now being marketed by Air Products and Chemicals, Incorporated. This system is similar to the multi-stage unit initially evaluated by Union Carbide at Batavia (see Section IV and Appendix A), except that mechanical aerators are utilized in lieu of the recirculating compressors and submerged propeller spargers (see Figure 7). Union Carbide is now also marketing a mechanical aerator version of their "UNOX" process. The first Air Products and Chemicals full-scale system was installed at the Fairfax County, Virginia Westgate Treatment Plant and has been operating since November 1971. This plant has a design

FIGURE 6

SCHEMATIC DIAGRAM OF U–TUBE OXYGEN TRANSFER DEVICE FOR PIPELINE REACTOR

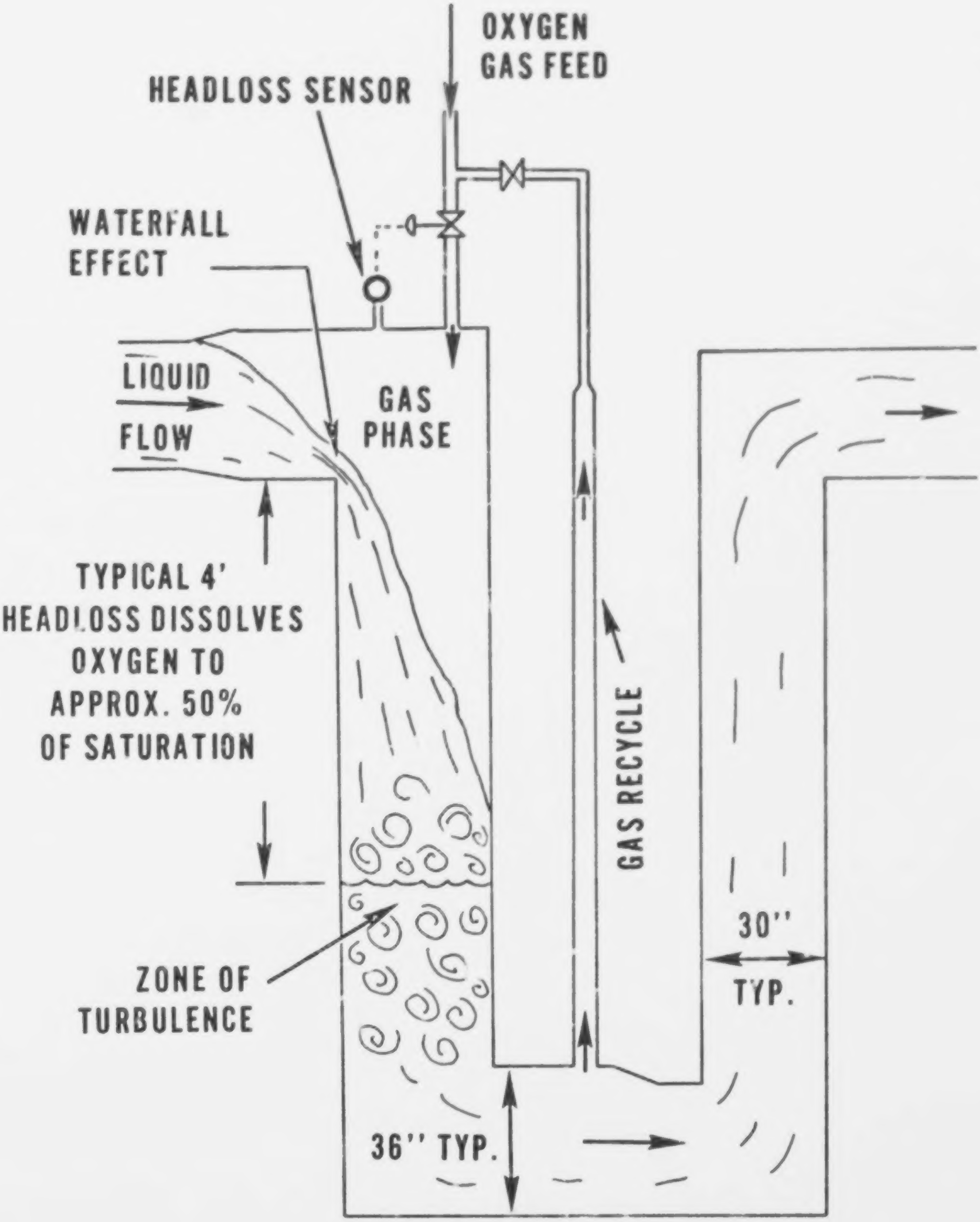
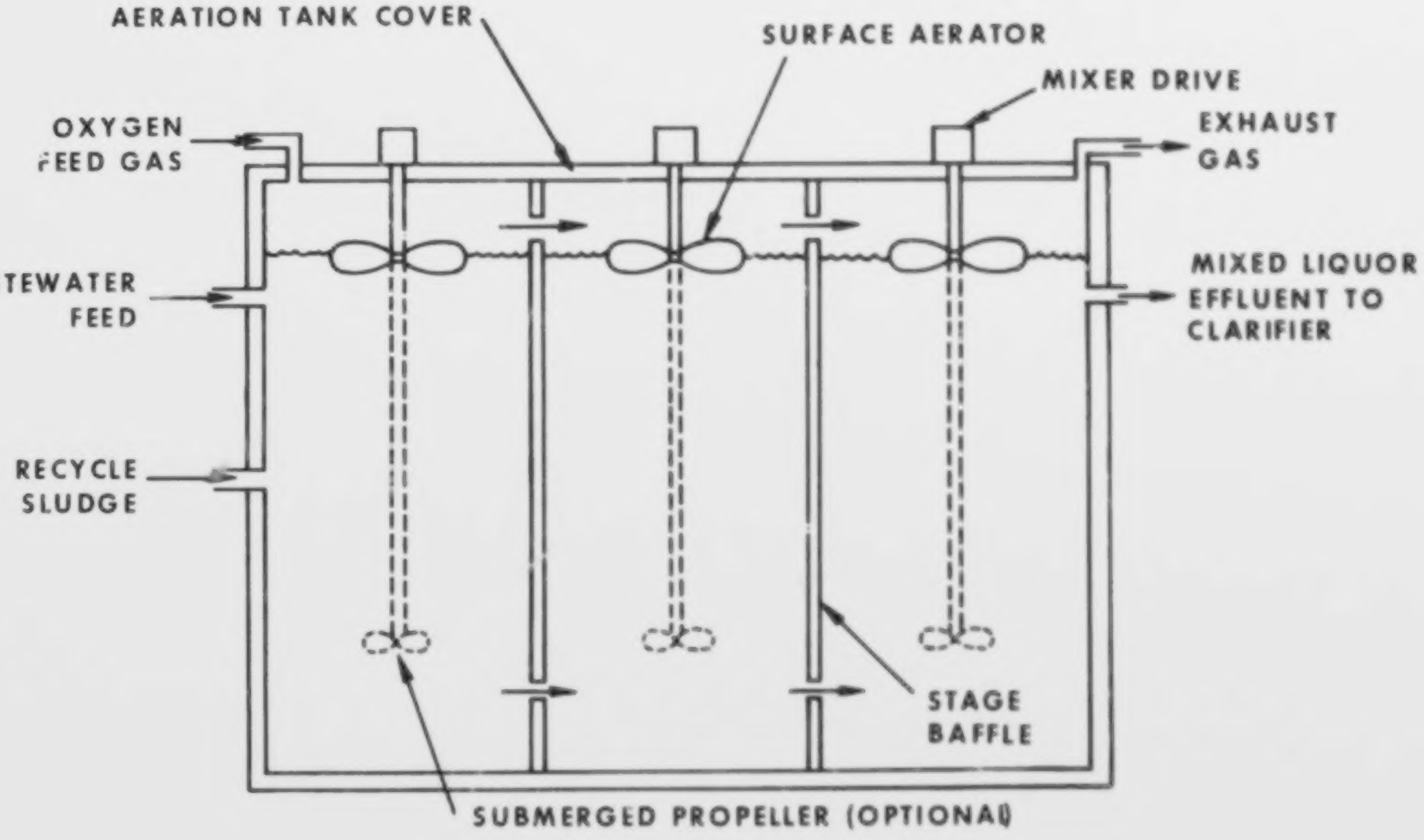


FIGURE 7

SCHEMATIC DIAGRAM OF MULTI-STAGE COVERED OXYGENATION SYSTEM UTILIZING SURFACE AERATORS



capacity of 12 mgd. The last reactor stage where oxygen demand is minimal is uncovered and utilizes standard mechanical air aeration.

The last oxygen aeration dissolution method described here has resulted from research efforts of the Martin Marietta Corporation. It differs from all other oxygen aeration concepts previously described in that it operates in open aeration tanks. The main feature of the proposed system is a novel diffuser which Martin Marietta claims has the ability to develop extremely fine oxygen gas bubbles (< 0.2 mm). Complete dissolution reportedly occurs in a tank with only 5 ft of liquid depth. It is claimed that the system achieves very high oxygen utilization efficiencies ($> 95\%$) and can be throttled to any desired dissolved oxygen level. A centrifugal pump is utilized to recycle mixed liquor from the aeration tank through the diffusers. Oxygen gas is injected into the diffuser bars at a pressure of about 30 psi. Both the recirculated mixed liquor and oxygen streams leave the diffusers through slit-type openings where the finely divided oxygen bubbles are quickly dissolved in the aeration tank mixed liquor.

A research and development grant was recently awarded to Martin Marietta to evaluate the feasibility of their open-tank oxygen aeration concept using a 30 gpm pilot plant. A sketch of the pilot plant unit is shown in Figure 8.

The largest grant to date was awarded to New York City in 1970 to demonstrate the "UNOX" recirculation compressor/submerged turbine system at a scale approximately ten times larger than Batavia. One of sixteen parallel bays was converted to oxygen at the City's Newtown Creek modified aeration plant. The design flow to the test bay is 20 mgd. Newtown Creek is confronted with an upgrading problem in a land-locked neighborhood (see Figure 9), a situation common to many large urban plants in the United States. The objective of this project is to demonstrate that an existing plant designed for 1.5 hours of nominal aeration time and 70% BOD removal can be upgraded with oxygen to 90% treatment efficiency without constructing new aeration tanks or secondary clarifiers. A sketch of the Newtown Creek oxygen test bay is shown in Figure 10.

FIGURE 8

PROPOSED OPEN-TANK OXYGENATION PILOT SYSTEM
MARTIN MARIETTA CORPORATION

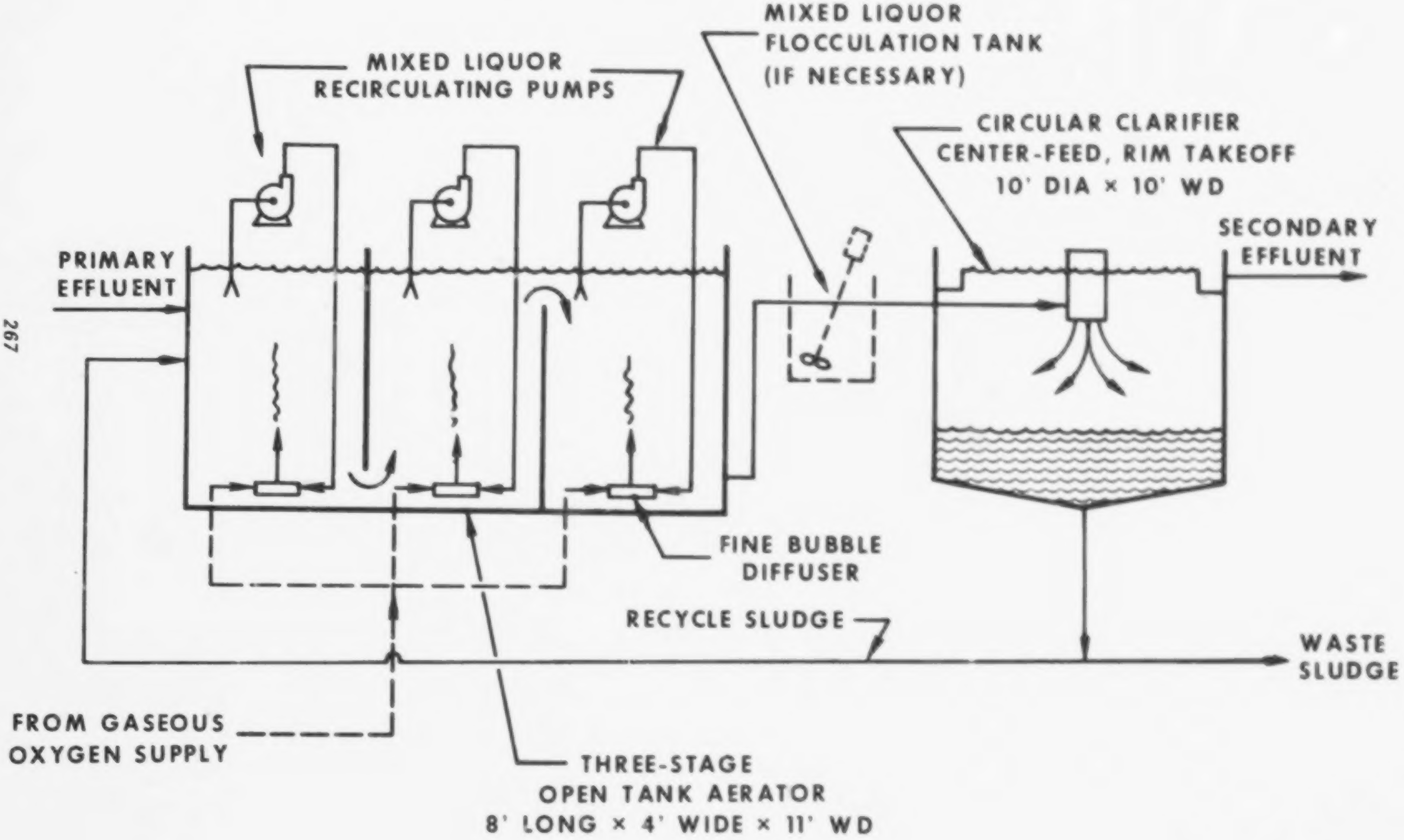


FIGURE 9

PLANT LAYOUT
NEWTOWN CREEK POLLUTION CONTROL PLANT
BROOKLYN, NEW YORK

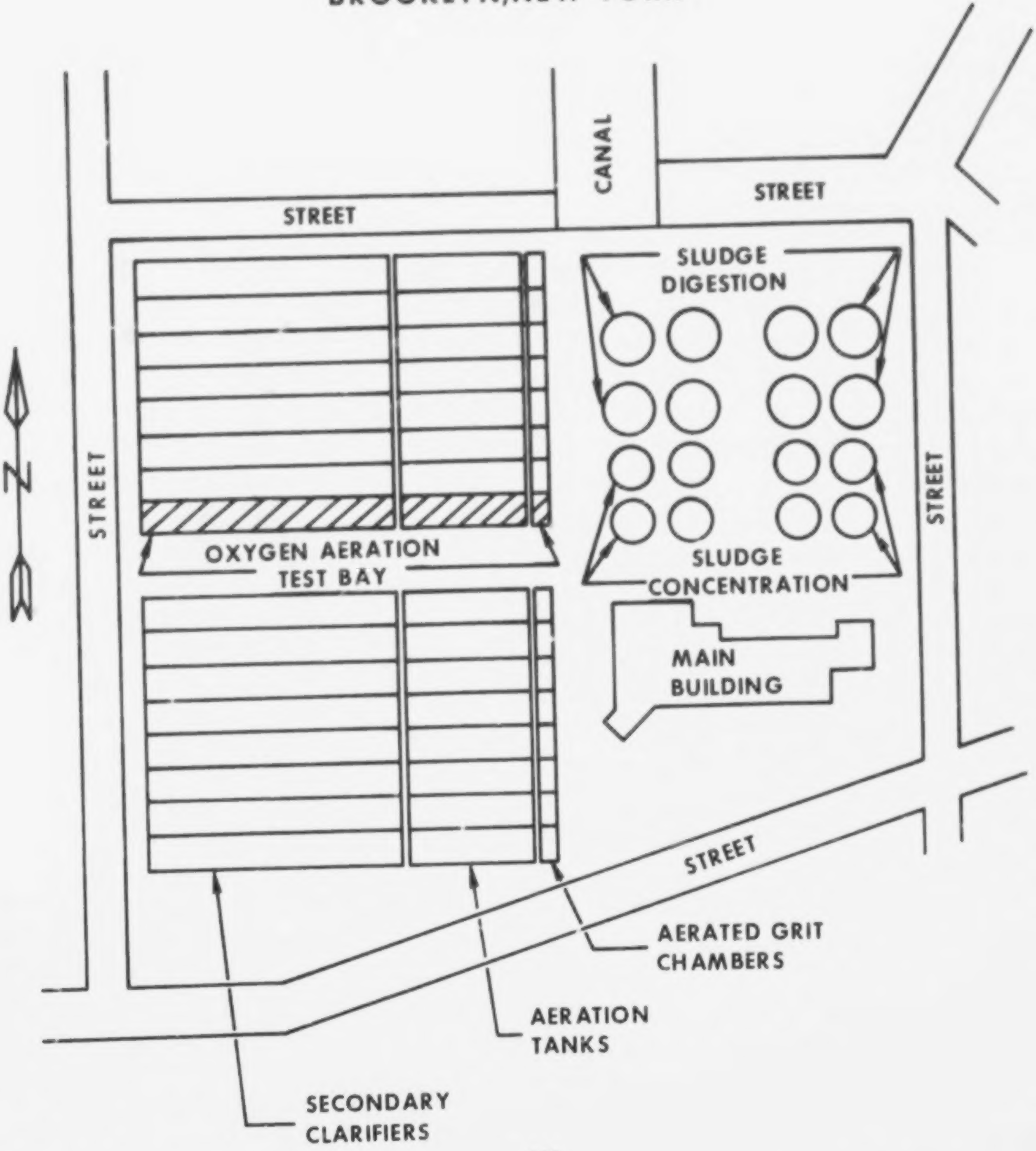
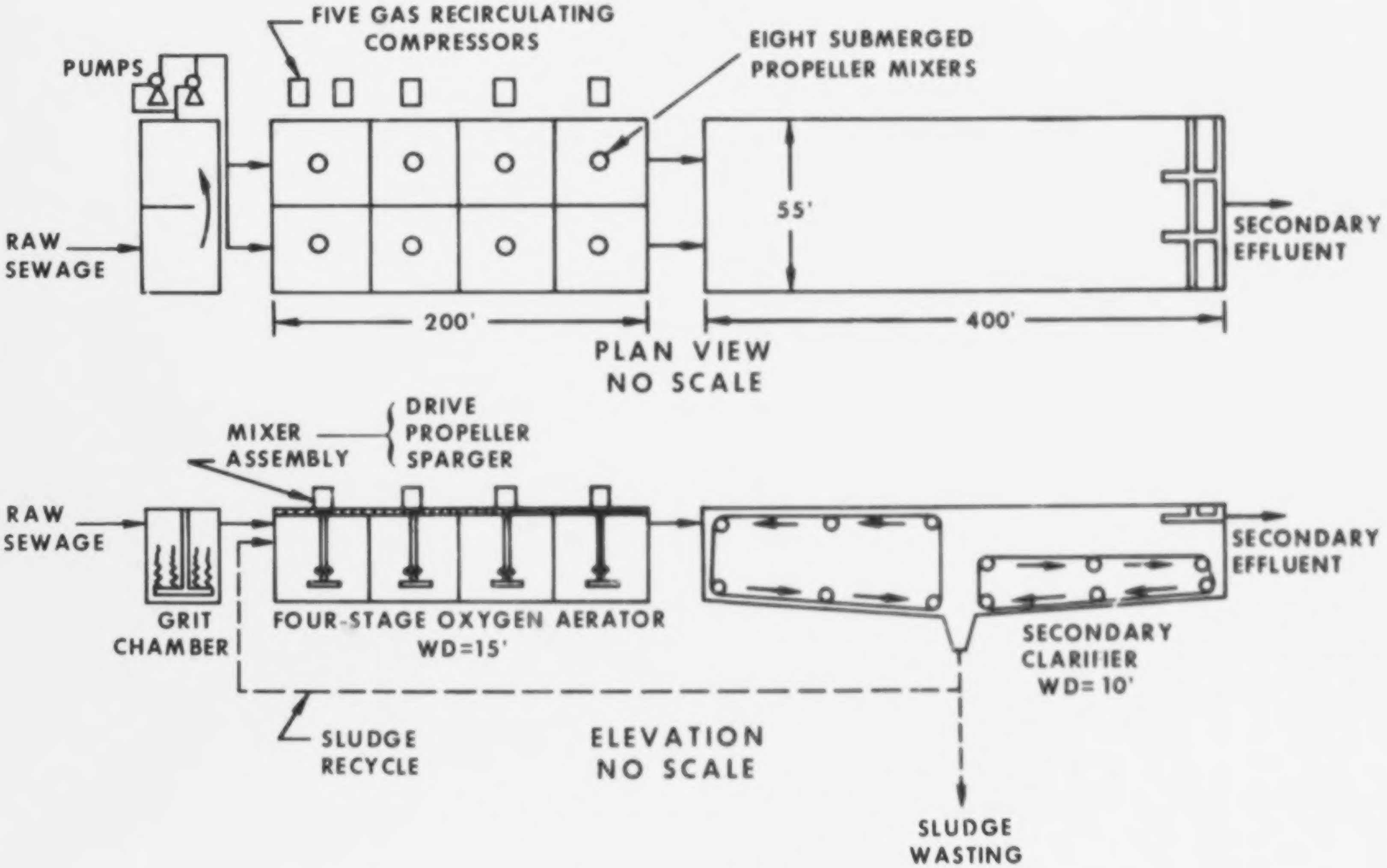


FIGURE 10

PLAN & ELEVATION VIEWS
OXYGEN AERATION TEST BAY
NEWTOWN CREEK



SLUDGE PRODUCTION AND DISPOSAL

1972

J. B. Farrell and R. B. Dean

State of the Art - Sludge Handling and Disposal

The treatment of sewage produces approximately

4 cu.ft. of grit	0.1 m^3
2 cu.ft. of skimmings	0.05 m^3
640 cu.ft. of sludge (5% solids)	18 m^3

per million gallons of sewage treated. 10,000 pe ; 4,000 m^3.

Grit and skimmings are highly polluted and noxious materials, but their quantities are not large enough to affect plant economy. They are ordinarily disposed of by burial or by incineration.

The sewage sludge stream is considerable: in volume it amounts to about one-half percent of the total sewage flow. It contains decomposing human and food wastes, viruses, bacteria, a variety of intestinal parasites, and in some cases, toxic chemicals and metals.

It is evident that sludge needs treatment before it can be disposed to the environment.

a) sludge can be stabilized biologically or chemically to reduce "putrefaction potential" and microbiological virulence. It can go directly to land or ocean disposal, or it can be dewatered before disposal.

b) it can go directly to dewatering without stabilization provided it is followed by some treatment such as heat drying or incineration which produces a sterile product.

Stabilization processes include:

Anaerobic digestion is by far the most commonly used method. It is an old process, thoroughly researched and developed. It is sensitive to poisoning by industrial chemicals and to poor operation. Digesters can be "sick" for periods of months, producing poorly stabilized sludge which is difficult to dispose of.

Aerobic stabilization is used by many small plants for stabilizing a sludge that is primarily biological. It is often followed by direct application to the land without dewatering.

Chemical treatment by lime sterilizes the sludge and reduces "putrefaction potential." It is not used much to date. It has potential for sludges containing chemicals which would inhibit biological processes. Chlorine treatment (Purifax) also sterilizes but produces toxic chemicals which require further treatment.

Heat treatment is used primarily because it makes the sludge far easier to dewater. It also sterilizes the sludge and greatly reduces "putrefaction potential." Unfortunately, it dissolves a substantial portion of the sludge. This enriched water stream must be reprocessed before it is returned to the treatment system. Variations of this process are offered by several U. S. firms (Zimpro, Porteous, Farrar, etc.) Many installations are being built or planned.

Dewatering. Probably 70 percent of the sludge produced at wastewater treatment plants is dewatered before disposal. Table I shows the types of equipment used along with some of their advantages and disadvantages. Dewatering of sludges is an expensive operation. Costs as high at $20 per dry ton are common. Biological sludges are the most difficult to dewater. Chemical and polymer conditioning can cost as much as $10 or in rare cases $14/dry ton.

Disposal. For ultimate disposal of the sludge, most wastewater treatment plants produce a stabilized sludge, dewater it on sand beds, vacuum filters, or centrifuges, and dispose it to the land.

Most of the sludge disposed to the land is dumped on the land. It is seldom covered, and, particularly around smaller plants, disposal is outside the plant grounds with no supervision or control or the dump site.

There are no firm figures on agricultural reuse of sludge. When there are small farms or golf courses in the vicinity of small communities, there can be substantial utilization of dried sludge. Some large cities dry sludge for use on their parks (San Diego).

Utilization of digested liquid sludge on the land is of considerable interest because it avoids the expensive dewatering step, and because it conserves useful values in the sludge. It is extensively practiced around small communities in Pennsylvania and Ohio and in scattered locations around the country (e.g., Miami, Florida). The most publicized user is the City of Chicago.

For approximately 10 percent of the sewered population, the sewage sludge is destroyed by incineration. The technology is well developed. Except for Los Angeles County where any incineration is virtually prohibited by fiat, incineration can be built to meet any existing air pollution requirements. Sludge incineration is far simpler than solid waste incineration, because particle size is small and uniform, incinerator loading is uniform, and heat of combustion is uniform. Incinerator ash is disposed of in landfills.

Table 1

Dewatering Equipment

Type	Advantages	Disadvantages
Rotary vacuum filters	High rate for floor space occupied.	Troublesome to operate and maintain.
Centrifuges (solid-bowl continuous)	Very high rate for floor space occupied. Totally enclosed.	High solids in the centrate. Maintenance is high.
Pressure filter	Produces a very dry cake.	Costly to operate.
Sand beds	Low first cost if land values are low. Can be operated with unskilled labor. Polymers not needed.	Large land area needed. Odoriferous. Much labor to clean.

Table 2

Incineration of Sewage Sludge

Principal Devices

Multiple hearth incinerator

Fluidized-bed incinerator

Advantages

a) Ash, though it can be 10% of the mass of the wet cake, is disposed of easily as a good fill.

b) The problem of disposal is handled within the plant boundaries.

Disadvantages

a) Poor operation can destroy a furnace.

b) If sludge has less than 25% solids, fuel cost will be high.

c) It may be necessary to keep certain substances out of sludge (e.g. mercury). This will impact on sewer system users.

Table 3

- MUNICIPAL SLUDGE RELATED TO POPULATION
- RAW SLUDGE: BEFORE PROCESSING
- PER CAPITA RATE OF RAW SLUDGE GENERATION (SECONDARY TREATMENT)

0.21 POUNDS/DAY, DRY BASIS	0.1 Kg/Day
95 - 98% WATER	
0.5 GALLON/DAY, WET BASIS	2 Liter/Day

- RAW SLUDGE FROM SECONDARY PLANT SERVING 100,000 PEOPLE

10.5 TONS/DAY DRY SOLIDS	10 Metric Ton/Day
50,000 GALLONS/DAY, WET VOLUME	2000 m^3/Day

Table 4

SLUDGE DISPOSITION TODAY

	TONS/DAY	METRIC/DAY	%
- OCEAN (OUTFALL, BARGE)	1650	1500	15
- INCINERATION	2750	2500	25
- LAND APPLICATION (LANDFILL, FERTILIZER, SOIL CONDITIONING)	6600	6000	60

Table 5

OUTLOOK FOR THE FUTURE - 1985

- OVERALL EFFECT: MORE SLUDGE

1972:	4.8	MILLION TONS/YR	4.4 METRIC
1985:	10.0	MILLION TONS/YR	9 METRIC

BAN ON OCEAN DUMPING WOULD LEAVE: INCINERATION, LAND APPLICATION, OTHER PROCESSES

Table 6a

RECENT PROJECTS -- APRIL 1972

ULTIMATE DISPOSAL

DEMONSTRATION

1.	Land Reclamation Through the Use of Digested Sludge (Chicago MSD)	Continuing
2.	Park Development with Wet Digested Sludge (Metro Seattle)	Completed*
3.	Microbiology of Sewage Sludge Disposal in Soil (Ohio ARS)	Completed*
4.	Development of Treatment and Disposal Methods for Septic Tank Sludges (University of Connecticut)	Completed*
5.	Utilization of Organic Matter in Waste Sludges -- PB 194 784 (Foster D. Snell)	Continuing in-house
6.	Porteous Process for Heat Treatment of Sludge (Lake County, Painesville, Ohio) -- plus in-house treatment of liquor.	Continuing
7.	Evaluation of a Top Feed Rotary Filter (Milwaukee, Wisconsin)	Continuation pending Dec. '72
8.	D.C. Sludge Pilot Plant (District of Columbia)	Continuing
9.	Aerobic Digestion of Sewage Sludge (Hollywood, Florida)	Completed*
10.	Evaluation of Conditioning and Dewatering Sewage Sludge by Freezing -- Published GPO (Milwaukee, Wisconsin)(Not economical)	Completed
11.	Sludge Slurry Pipeline and Strip Mine Reclamation (Morgantown, West Virginia)	Completed*
12.	Application of Enzymes for Sludge Dewatering (Aerojet-General) PB 207 480 (Not economical)	Completed
13.	Fly Ash Aid of Sewage Solids Dewatering and Disposal (Cedar Rapids, Iowa)	Continuing

* Work Completed, Final Report not yet published.

Table 6b

NEW PROJECTS SINCE APRIL 1972

14. Oil Flotation of Sludge (Esso)
15. Capillary Belt Filter (Westinghouse-Infilco)
16. Magnetically Assisted Dewatering of Waste Activated Sludge (R.P. Industries)
17. Lime Sludge Study (Central Contra Costa Sewage Treatment Plant, Walnut Creek, California)
18. Centrate Dewatering Study (LACSD, California)
19. Survey of Land Spreading (Battelle, Columbus, Ohio)
20. Lime Stabilization of Sludge (Battelle-Northwest, Richland, Washington)
21. Phosphate Sludge Disposal in Forest Area (Ely, Minnesota)

Table 7

IN-HOUSE ACTIVITIES

ULTIMATE DISPOSAL

1. Properties of Physical-Chemical Sludges
2. Testing Pilot-Scale Dewatering Equipment
3. Aluminum and Iron Sludges Recovery and Reuse
4. Evaluating Conditioning Sludge with Sludge Ash and Polymers
5. Determining Metals Buildup with Sludge Application
6. Determining Influence of Type of Sludge and Soil on the Growth of Several Plant Types
7. Analyzing for Metals, PCB's, etc., to Determine Quantities and Fate on Disposal
8. Treatment of Liquors from Porteous Process, etc.
9. Task Force on Mercury and Other Heavy Metals in Sludge
10. Task Force on Alternatives to Ocean Dumping

FACTORS TO CONSIDER IN THE SELECTION OF A CONTROL STRATEGY

by

Joseph F. Roesler

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National Environmental Research Center
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Cincinnati, Ohio

May 1972

FACTORS TO CONSIDER IN THE SELECTION OF A CONTROL STRATEGY

Joseph F. Roesler

Automation in wastewater treatment is a new area with new challenges. The instrumentation and control strategies developed in the chemical process industries will be used wherever possible. Wastewater treatment has some unique technical problems, such as long detention and process response times, slime growths and solids buildup. It is a conservative field and the normal questions concerning performance improvements, process reliability and economic savings not only need to be answered, but must also be demonstrated. Furthermore, even though automatic control equipment was designed into a plant, it appears that it would be the intention of some planners to operate the plants manually. In these cases, the instrumentation and computers would be used for collecting, storing, and analyzing plant data. This new area of instrumentation and automation is now being studied at the National Environmental Research Center in Cincinnati, Ohio.

Successful automation of the plant depends on the proper selection of control strategies and their interrelationships. The criteria that one should consider prior to selection of a control strategy are:

A) the availability of the analytical instruments and control devices,

B) the feasibility of the control strategy,

C) the performance improvement of the process, and

D) the economic savings.

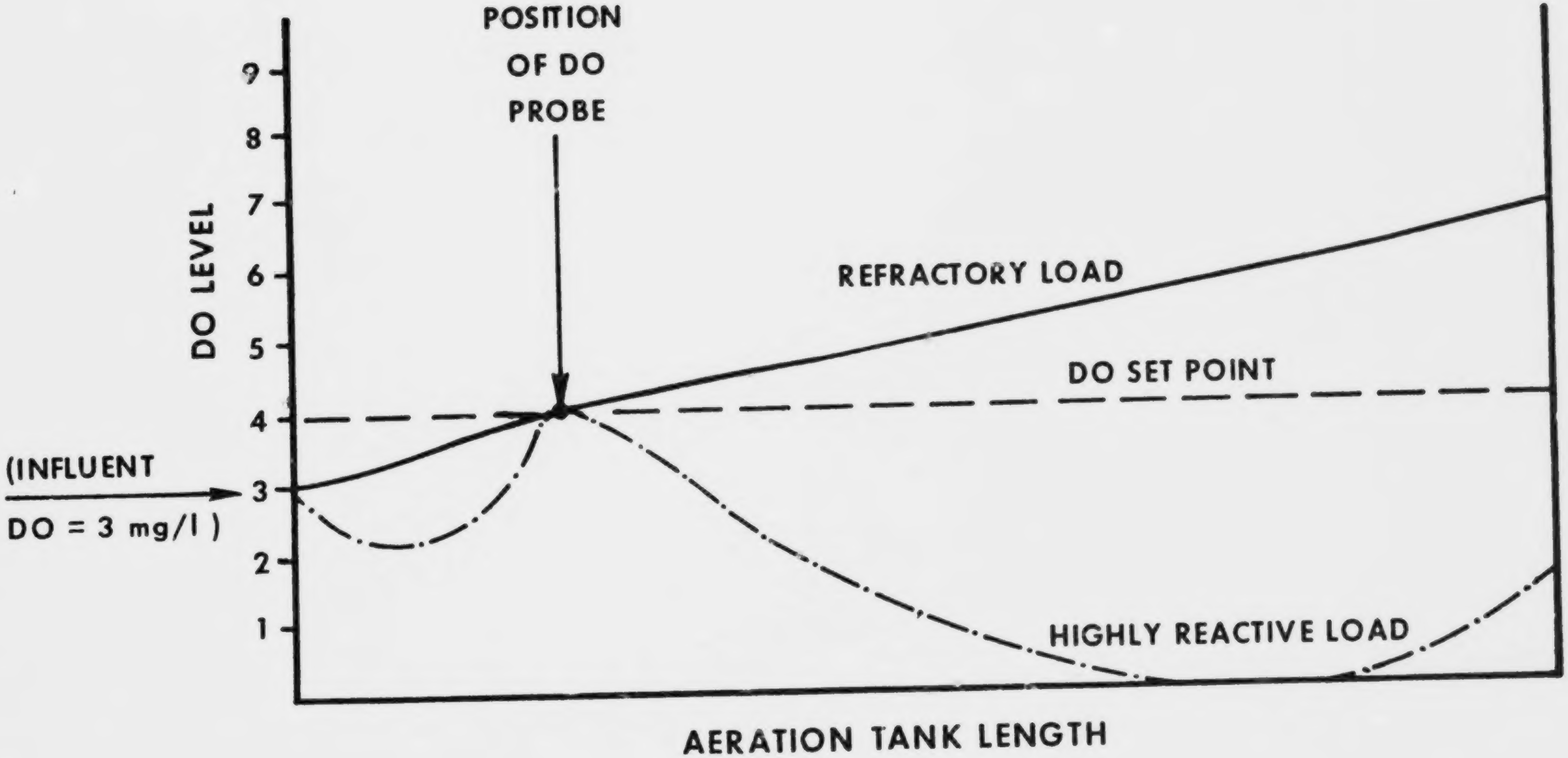
As an example of the first criterion, consider the control of the conventional activated sludge process. From a theoretical viewpoint, the process is a conversion of food into microorganisms in an aerobic environment. The process variable are the substrate variables, (BOD, TOC, etc.), the mass of organisms (MLSS, MLVSS) and the amount of oxygen supplied (air flow rate, DO). If the control strategy is based on a measurement of a substrate variable, then an example of one limitation would be the lack of a BOD analyzer. Automatic on-line TOC and COD analyzers are relatively new and have not been thoroughly evaluated for this sort of application.

If a proven reliable substrate analyzer were available, the designer would be faced by two alternative choices for a control strategy: 1) feedforward control and 2) feedback control. In feedforward control, the product of the flow and the substrate variable entering the aerator represents the amount of food available. Using a mathematical relationship, the air flow rate and the return sludge are measured and regulated. In feedback control, the flow and the substrate variable of the effluent are measured and again the air flow rate and return sludge are regulated. This is not as precise a control as feedforward control. It is essentially a trial and error approach to finding the optimum setpoint, and is highly dependent on the response time of the process. Consider the case of plug flow aeration where the detention time is about 4 hours and it is easy to understand why a feedback substrate control loop is not feasible.

Because of this, many plants are using indirect methods of control, for example, an air sludge recycle cascade control strategy. These plants recognize the difficulties of automatic substrate measurement and effluent quality control. Indirect measurement and control consist of monitoring parameters such as DO, return sludge, sludge level, blower horsepower etc.

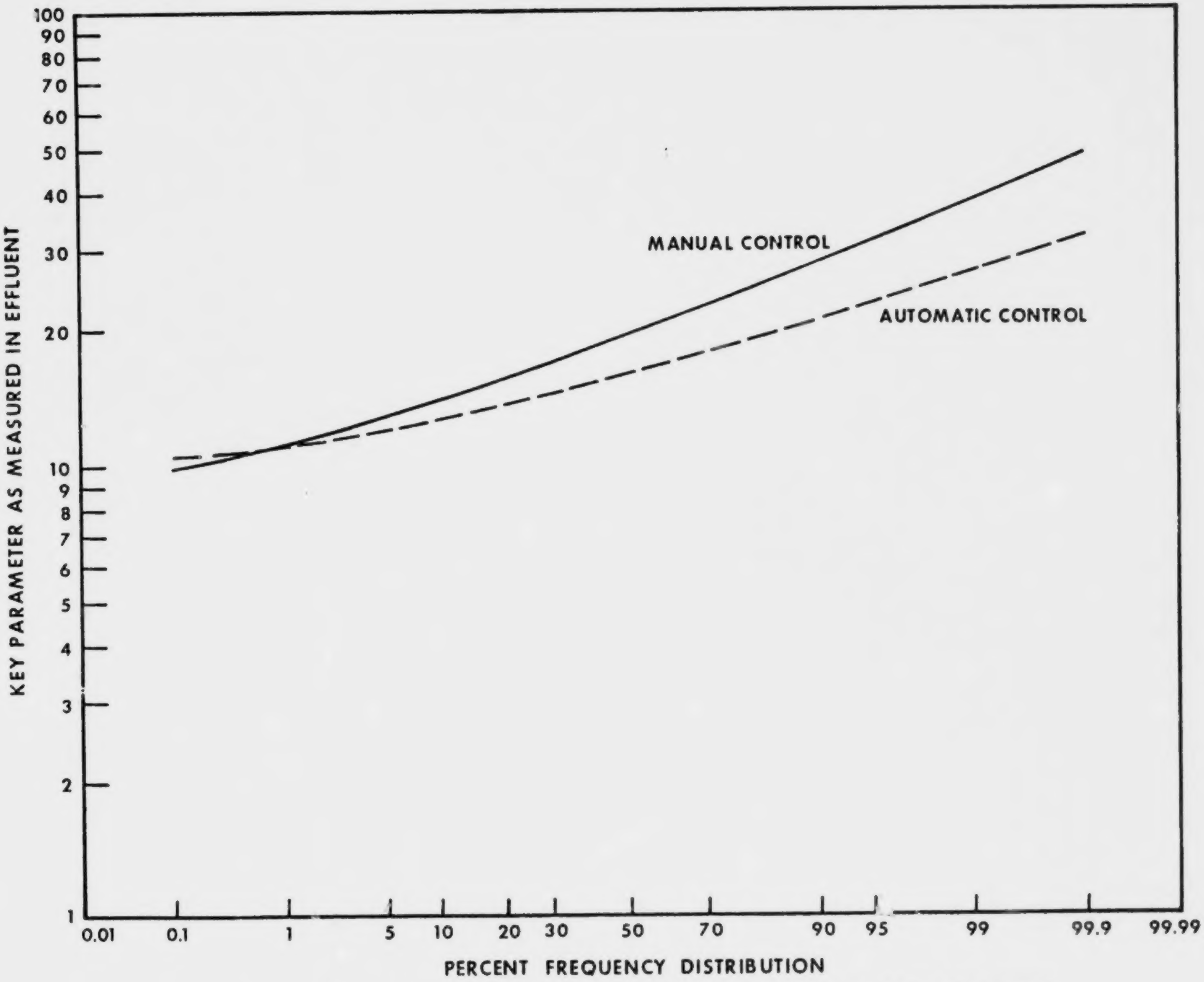
If indirect methods of control are used, the position of the analytical probes are very important. Consider Figure 1. The DO probe has been placed near the influent to the aeration tank. Note that a highly reactive load, on entering the tank, consumes oxygen very rapidly. The position of the DO probe and the DO set point ensures that only at that point within the aeration tank would the DO remain at that fixed level. As the highly reactive load leaves the tank, it gradually becomes anaerobic, there being insufficient oxygen supplied to the tank to accommodate the high BOD loading. On the other hand, a DO probe at the same location with the same set point will record a constant increase in dissolved oxygen with a refractory load passing through the tank. This is a disadvantage of indirect control. The control devices are performing properly; however, the quality of the effluent may be very poor.

In considering a potential control strategy, one should consider the projected performance of the plant using the control strategy as compared to no control at all. Figure 2 represents a plot of the statistical variability of some key parameter which is a measure of the effluent quality. The two curves represent the operation of the same plant by manual and automatic control. Note that there is a point on the graph where the concentration of the key parameter is identical for both manual and automatic control. Since it is not possible for the operator to monitor and control the key parameter 100% of the time, the key parameter will begin to run wild as indicated by the increased slope of the curve. With automatic control, the key parameters are continually monitored and controlled, resulting in a lesser slope of the above curve and a performance of the plant that is more dependable. The intersection of the manual and automatic control curves is a function of the amount of time that the operator can spend in monitoring and controlling the key parameter.



DO CONTROL AT ONLY ONE POINT FOR UNIFORM DIFFUSED AERATION

FIGURE 1



STATISTICAL VARIABILITY OF WASTE TREATMENT PLANT EFFLUENT

FIGURE 2

The economics associated with the selection of a control strategy are probably the most vital criterion. Consider four alternative control strategies for removing phosphate by precipitation with alum. In Figure 3, the phosphate loading is given for a 10 mgd plant. The four alternative control strategies are: A) addition of a fixed amount of alum to precipitate out the maximum amount of daily phosphate loading; B) two daily dosage levels of alum feed as determined by the operator for diurnal high and low variations of phosphate; C) alum addition as a function of flow, and D) alum addition as a function of mass loading of phosphate. The annual cost, considering only the cost of the alum and the alum storage capacity required, are given in Table 1. Costs were based on liquid alum addition at \$46.90/ton of 17.15% dry Al_2O_3. To remove one mole of phosphorus a 1.5 mole of aluminum was required.

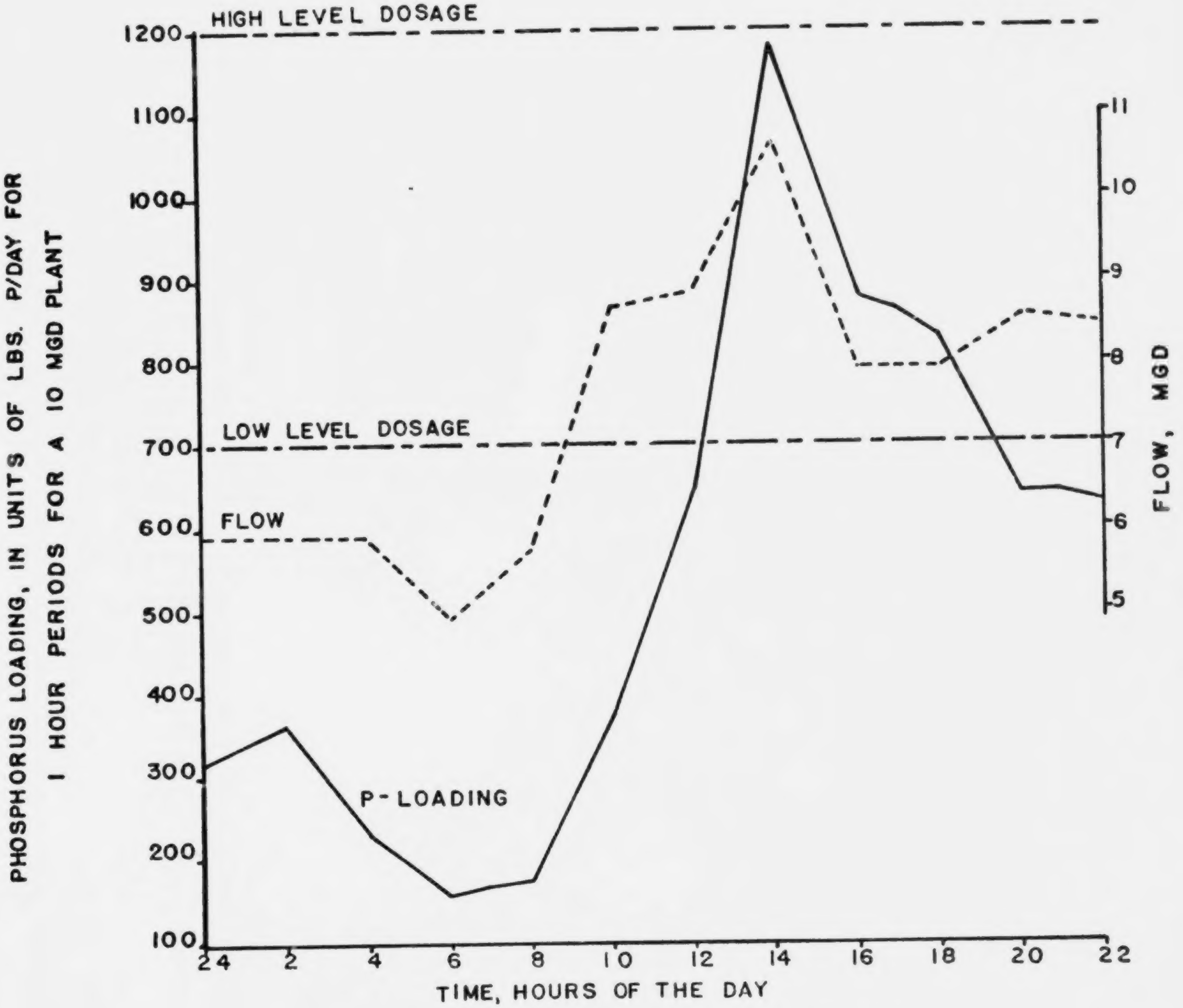
Table 1

Cost Effectiveness of Alternative Control Strategies for Phosphorus Removal with Alum (10 mgd plant)

	Control Scheme	Liquid Alum Required 1000 lbs/day	Annual Cost (\$1000)	Savings (\$1000)
A)	Max. Daily Dose	35.7	156	0
B)	Operator Control	28.3	127	29
C)	Flow Proportional	26.9	121.5	34.5
D)	Mass Proportional	16.3	81	75

The cost of control equipment and savings in sludge disposal were not considered in the above analysis. Note that by having a control system that monitors both the phosphate and the flow (control Scheme D) there is a potential economic savings of approximately \$75,000 per year over no control at all (control Scheme A).

A mass proportional control strategy solution may not be the most cost effective solution for all particular problems. Consider the addition of methanol for the denitrification process. Four alternate control strategies are again employed: A) addition of maximum methanol with supplementary aeration to remove excess methanol; B) operator control with analytical chemists monitoring the process; C) flow proportional control; and D) mass proportional control. The costs listed in Table II are the excess costs when the control scheme is compared with no methanol addition and no supplementary aeration.



PHOSPHORUS LOADING AND FLOW
FOR A 10 MGD PLANT

FIGURE 3

Table II

Economic Advantages
of Various Control Schemes for 10 Mgd
Denitrification Process

Control Scheme	Excess Costs $/Year
A) Max. Daily Dose	$24,250
B) Operator Control	21,800
C) Flow Proportional	1,850
D) Mass Proportional	2,550

Adding the maximum amount of methanol has to be compensated for by a large aeration tank to remove the excess methanol. For operator control, little excess methanol will remain but the cost now reflects a chemist continuously analyzing and adjusting the methanol so that the excess methanol is regulatable. Flow proportional control will also result in little excess methanol which may be regulated. These excess costs also include the cost of instrumentation and control devices. Note that when these costs are considered, mass proportional control is more expensive than flow proportional control. In this particular example, flow proportional control is the most economical control strategy that can be used.

Which parameter to control and which control strategy to be used are necessary considerations in the design of automatic waste treatment plants. These factors will influence the performance and effect the plant economics. There are no general answers at this time and each individual case must be evaluated on its own merit.

WASTE TREATMENT FOR SMALL FLOWS

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WASTE TREATMENT FOR SMALL FLOWS*

J. F. Kreissl**

It can be safely stated that the main thrust of waste treatment research in recent years has been concerned with large municipal and industrial sources. The logic to such an approach is obvious from Figure 1. Since approximately 75 percent of the total population of the United States is located in urban areas, large municipal systems represent the most profitable form of pursuit in terms of pollution abatement. The economics of municipal wastewater collection have been discussed by Smith and Eilers(1). The cost of sewer construction on a per capita basis was found to be related inversely to the population density as shown in Figure 2. Interpolation of these costs to rural area conditions of lower densities and larger lot sizes and consideration of needs for force mains and pump stations due to topographical conditions leads one to the conclusion that costs become prohibitive.

Similar "economics of size" have been computed for the treatment of municipal wastes. Figure 3 shows the costs for such a plant treating from 1 to 100 MGD of municipal wastewater(2). A well-run plant of this type can be expected to remove 85 to 95 percent of the organic and particulate matter from wastewaters. It should be noted that nitrogen and phosphorus removals are usually minimal in such an installation. In many instances water quality standards will require relatively complete removal of phosphorus and, in some cases, nitrogen to protect the receiving stream and increase the cost of treatment significantly.

The average community served by a sewer system and treatment plant has a daily flow of 7 to 10 MGD. The breakdown of costs per capita paid by the 1968 user are shown in Table I(1). The total figure of $19.80 does not represent the actual cost of these facilities because of the general lag in sewer charges assessed by municipalities. In addition, these costs may be significantly higher for a more diffuse rural area where more sewerage per capita is required.

Other negative factors for rural wastewater problems include the intermittent flow patterns of wastewaters. Although municipal flows also have distinct diurnal flow variations, individual and small groups of homes will greatly accentuate the "spikey" nature of the pattern. One must also consider that the need for proper operation of any waste treatment facility will require some amount of physical attention or instrumentation. Some special problems of individual home wastewaters also exist which further differentiate them from those of a municipal nature. In general, individual sources exhibit much stronger wastewater in terms of suspended solids, organic matter, nitrogen, phosphorus, and grease, as shown in Table II. This is due to the fact that municipal systems are subject to infiltration from ground- and storm-water as well as numerous other types of dilution.

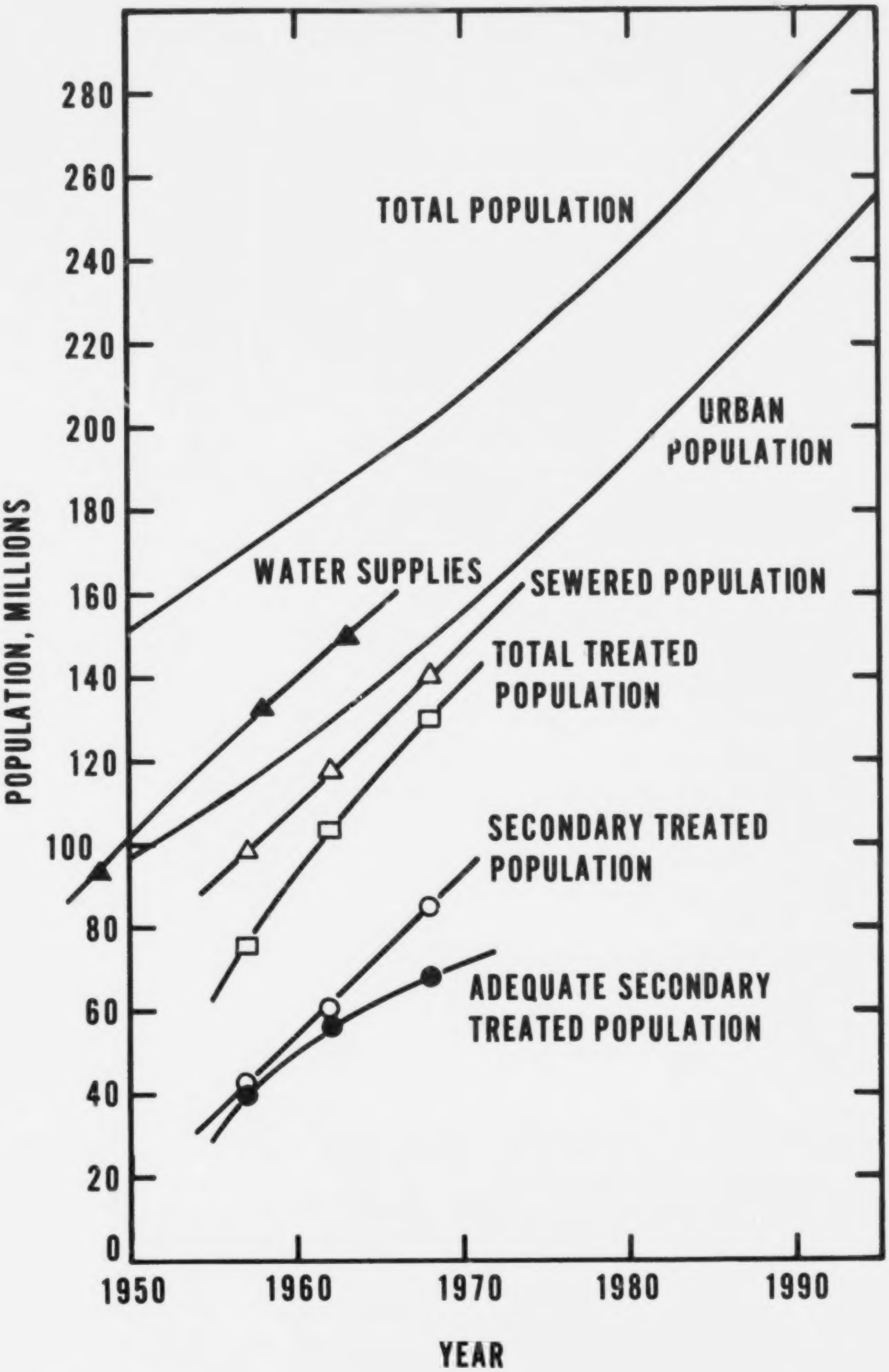


FIGURE 1
STATUS OF MUNICIPAL WASTEWATER TREATMENT FACILITIES IN THE UNITED STATES

COST OF SEWERAGE COLLECTION SYSTEMS
WITHOUT
PUMPING STATIONS
VERSUS
POPULATION DENSITY
1968 DOLLARS

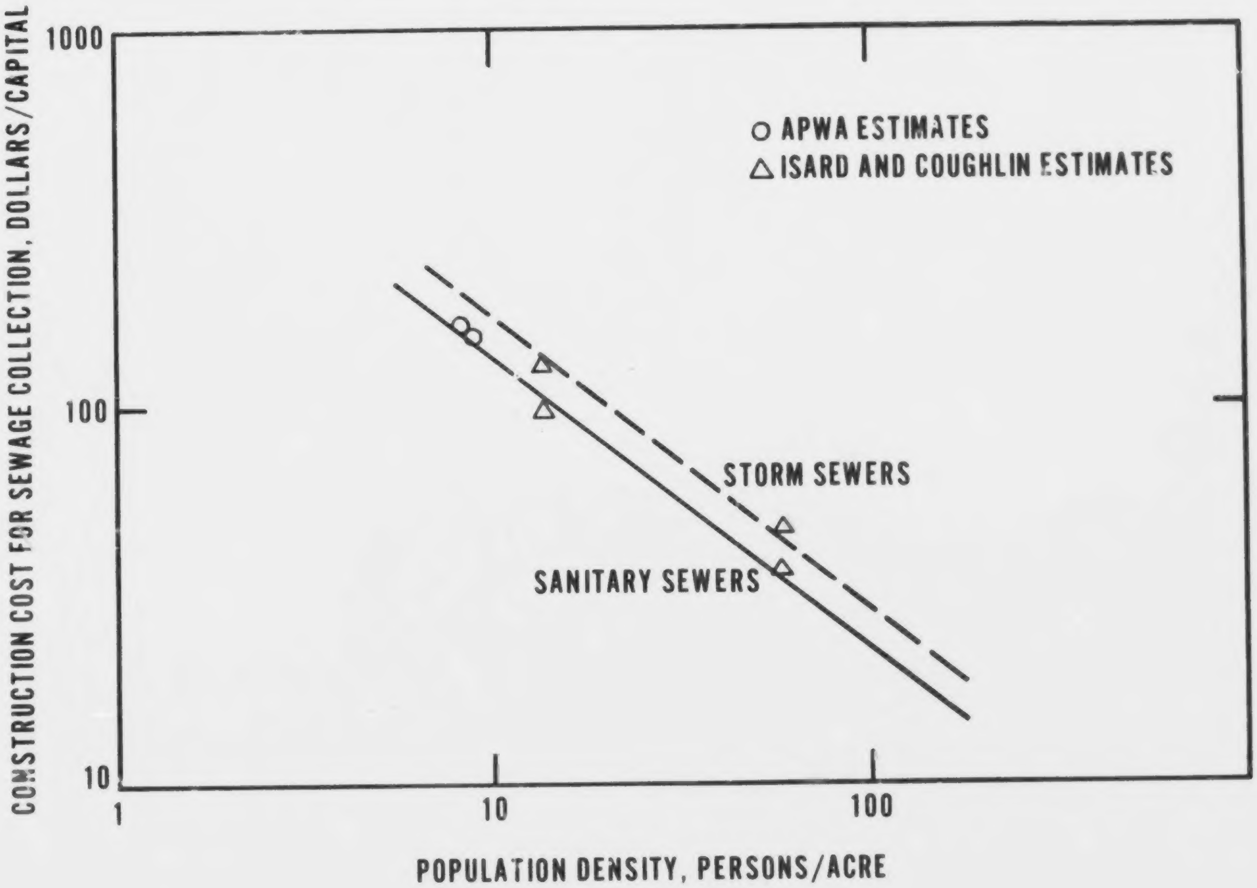
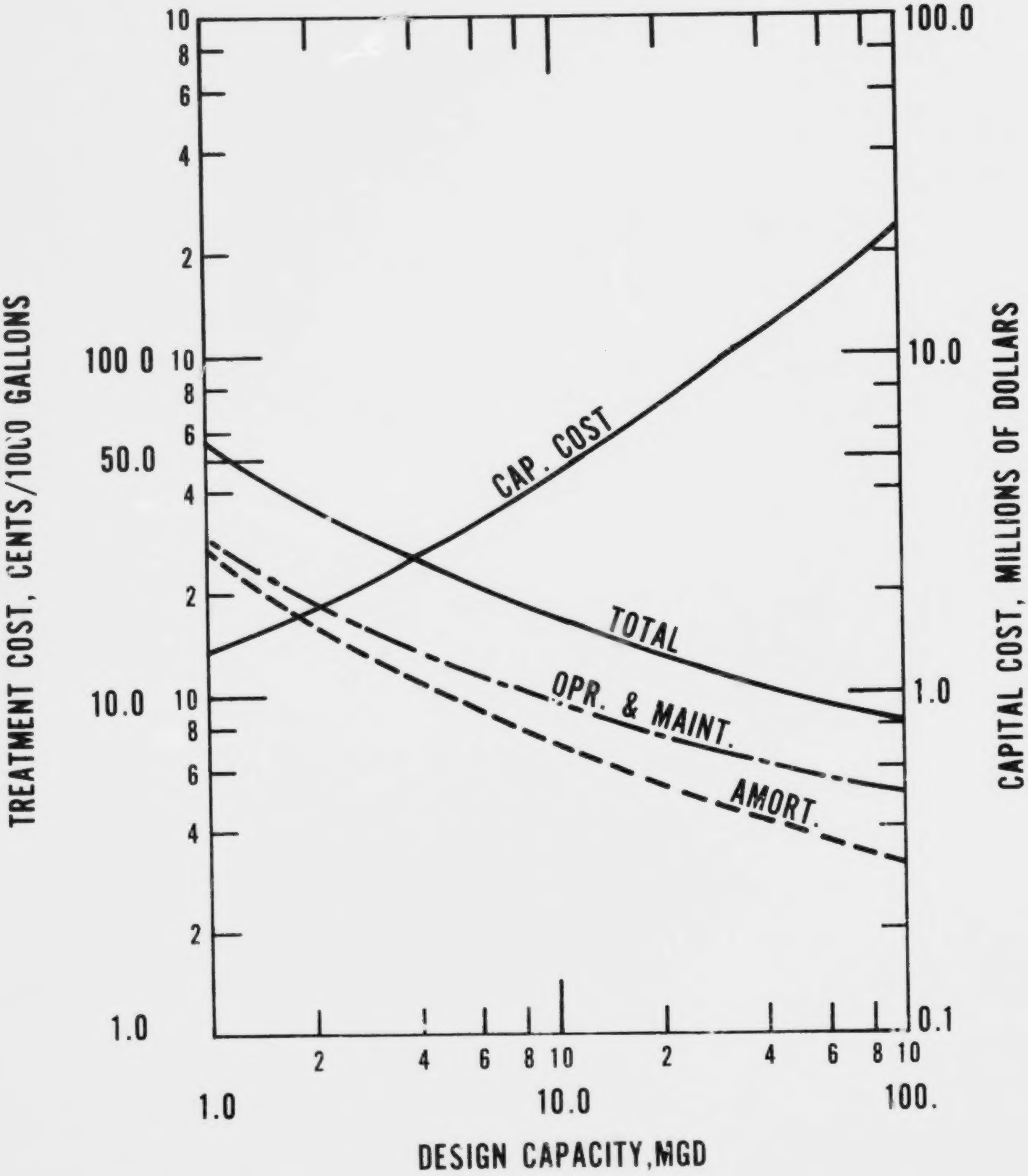


FIGURE 2

FIGURE 3

COST ADJUSTED TO JANUARY,1970



ACTIVATED SLUDGE PLANTS

TABLE I

TOTAL COST OF SEWAGE COLLECTION AND TREATMENT IN 1968 ON A CONTINUOUS CASH FLOW BASIS

1968 dollars/capita/year

Amortization Cost		
House Connection	$1.38	
Municipal Sewers	$8.64	
Interceptors and Outfalls	$2.46	
Treatment Plants	$2.83	
Total Amortization Cost	$15.31	
Current Expenses		
Municipal Sewer Maintenance		$0.86
Treatment Operation and Maintenance		$1.55
Customer Service and Accounting		$0.71
General and Administrative		$1.37
Total Current Expenses		$4.49
Total Cost of Municipal Collection and Treatment	$19.80	

TABLE II

WASTE CHARACTERIZATION

PARAMETER (UNITS)	TYPICAL MUNICIPAL SEWAGE	HOUSEHOLD WASTEWATER W.GRINDER	HOUSEHOLD WASTEWATER W.O.GRINDER
SUSPENDED SOLIDS, mg/l	200	480	380
COD, mg/l	350	910	710
BOD_5, mg/l	210	490	435
TOTAL NITROGEN, mg N/l	33	105	84
AMMONIA, mg N/l	12	81	64
TOTAL PHOSPHORUS, mg PO_4/l	24	57	61
GREASE, mg/l	14	89	65

As these negative aspects become apparent, one might well ask what the answer to this problem might be. Surely, one answer is planning. In areas of growth around urban centers an official master plan of that region becomes an effective tool for determination not only of the physical layout of the area, but also for determination of sewerage needs. By constructing these facilities along with the housing structures, much difficulty is avoided. If interceptor sewers cannot be extended at the time of construction, it is a relatively simple matter to provide a temporary "package" waste treatment plant at the point of sewage discharge from the new development.

It is painfully true that master plans are generally scarce and limited to larger urban centers. In the absence of the physical criteria put forth in these documents there is a need to make decisions concerning wastewater problems. As a rule, it always is desirable to provide for central collection and treatment of wastes. The costs previously noted must be taken into account along with the sociopolitical considerations as to future development of the area. Unfortunately, where insufficient regulation is involved, many developers have opted for individual systems because of their more clearly defined cost to the individual home (5). In many areas such systems are not suitable due to the soil's inability to accept the volume of wastewater generated or due to their proximity to lakes and streams creating the possibility for pollution. The suggested distances between the various components of an individual household sanitary system are illustrated in Table III. In addition, the size of an absorption field is dependent on the results of preliminary percolation tests. It is readily apparent that the use of a private well coupled with a poor soil permeability will require prohibitively large land areas for individual homes.

Numerous situations exist where individual systems are the only feasible method of waste treatment. These are generally due to the inherent isolation of the dwelling. Small systems include such things as farms, isolated rural homes, fishing cabins, hunting cabins, and the like. Larger installations which are prevalent include ski resorts, highway rest areas, park facilities, schools and hospitals, work camps, and numerous other isolated facilities producing large quantities of wastewater.

Individual Homes

Household water use is a function of the number of residents, standard of living, utilization of climate, and personal habits. Estimates vary from 20 to more than 100 gallons per capita per day (gpcd) when lawn sprinkling is excluded. (5) Water usage per capita is generally found to be inversely proportional to the number of residents per dwelling due to certain relatively constant household requirements, and directly proportional to the standard of living because of increased utilization of water-consuming modern appliances. A recent study (5) estimated that an average home of two adults and two children has a water-use breakdown as shown in Figure 4. This survey also concluded that water used in bathing, toilet flushing, and laundering can be economically reduced by more than 35 percent with commercially available devices. A partial listing of the feasible devices available for water savings in the home are shown in Table IV

TABLE III

MINIMUM DISTANCE BETWEEN COMPONENTS OF SEWAGE DISPOSAL SYSTEM

COMPONENT OF SYSTEM	HORIZONTAL DISTANCE (FEET)				
	WELL OR SUCTION LINE	WATER SUPPLY LINE (PRESSURE)	STREAM	DWELLING	PROPERTY LINE
BUILDING SEWER	50	10	50		
SEPTIC TANK	50	10	50	5	10
DISPOSAL FIELD AND SEEPAGE BED	100	25	50	20	5
SEEPAGE PIT	100	50	50	20	10
CESSPOOL	150	50	50	20	15

FIGURE 4

AVERAGE HOUSEHOLD WATER REQUIREMENTS
FOR A FAMILY OF 2 ADULTS AND 2 CHILDREN

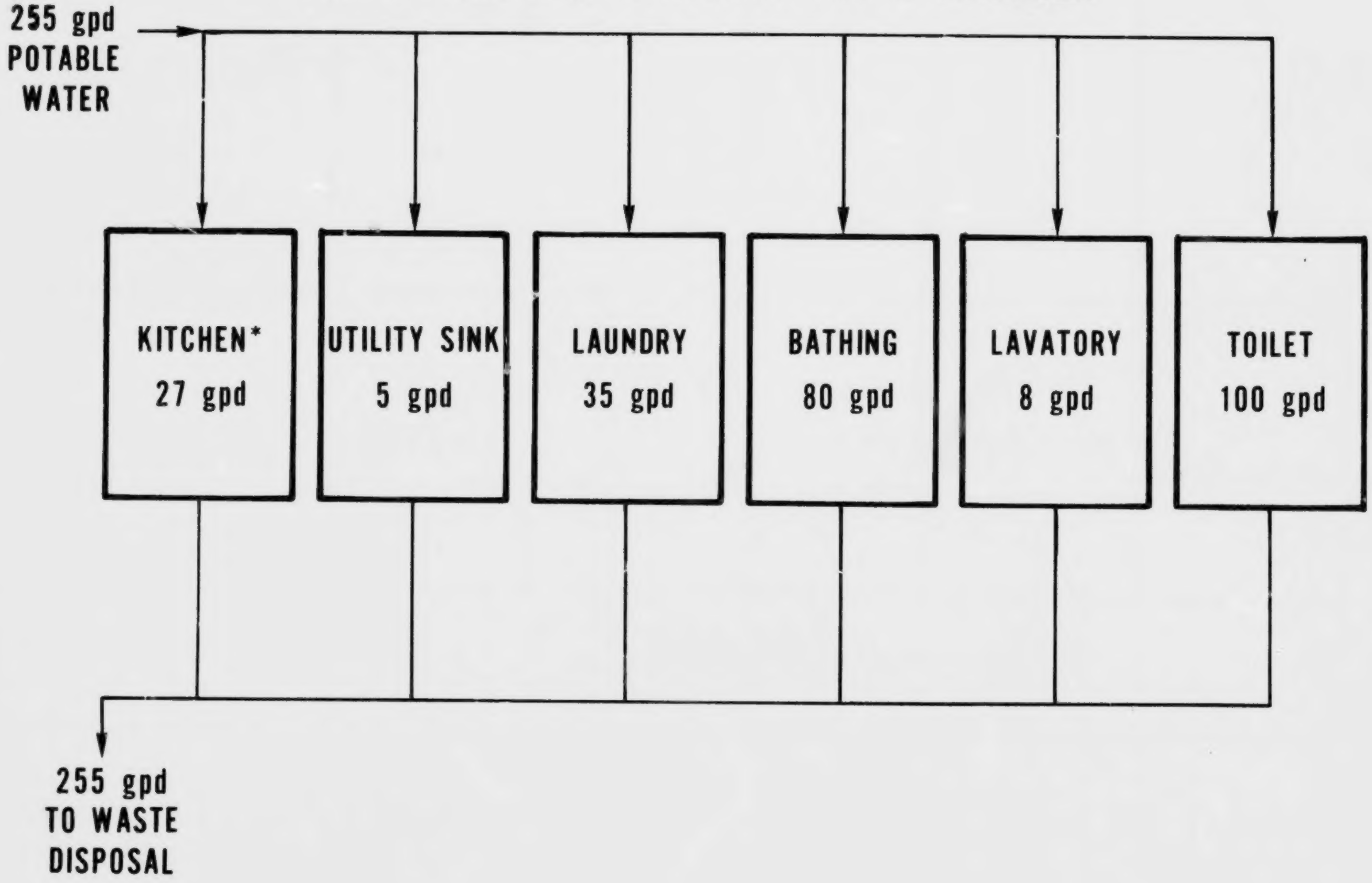


TABLE IV

WATER SAVINGS vs COST FOR PLUMBING DEVICES

	WATER SAVINGS		NEW CONSTRUCTION ESTIMATED COST		OLD CONSTRUCTION ESTIMATED COST	
HARDWARE DEVICE	gpcd	gpd	MATL.	INSTALLED COST	MATL.	INSTALLED COST
LIMITING FLOW VALVES FOR SHOWER	6	24	15	15	35	50
LIMITING FLOW VALVES FOR LAVATORY	0.5	2	25	25	45	68
LIMITING FLOW VALVES FOR KITCHEN SINK	0.5	2	25	25	45	68
AERATOR FOR LAVATORY AND KITCHEN SINK	0.5	2	2	2	2	2
DUAL CYCLE WATER CLOSET	17.5	70	10	10	100	130
WASHING MACHINE WITH LEVEL CONTROL	1.2	5	35	35	35	35

along with their estimated installation costs and water savings potential (5). Reduced water consumption will result in correspondingly high concentrations of pollutants. The effects of this situation on home wastewater treatment will have to be determined. A study of this type is proposed for funding by the Environmental Protection Agency in the near future.

The traditional means of waste treatment for individual homes is the septic tank-soil absorption system depicted in Figure 5. In cases where these installations are properly designed and soil conditions are satisfactory, good results are obtained when proper servicing of the system is afforded. Failure of these systems is most often exhibited by a failure of the soil absorption system. Causes of such failures may be due to inadequate soils, improper leach-field construction techniques, or malfunctioning septic tanks due to poor construction or inadequate servicing. Some variations on the septic tank-soil absorption system have been marketed. A limited amount of data have been generated on these systems at this time, however.

A number of people feel that a good aerobic effluent will significantly reduce the area needed for soil absorption fields. With superior organic and solids removal, the two major causes of soil clogging are reduced. A number of manufacturers offer these individual home aerobic treatment devices to the public. Although they are more expensive than the simpler septic tanks, their higher performance level may justify the expenditure.

The number of septic tanks in use today is estimated at more than 17 million, including cesspools. Some 5 to 10 million primitive systems, i.e., the pit privy and similar devices, are still in use. Between 20,000 and 30,000 home aerobic treatment systems are estimated to be in use presently (5). A typical septic tank installation includes a collection line from the house; a septic tank; a distribution box, in some cases; and a soil absorption system. Cutaway drawings of the septic tank and absorption systems are illustrated in Figures 6 and 7. The septic tank is basically a settling tank and low-rate digestion system allowing for solids settling (sludge) and floating (scum) with concomitant liquefaction of solids. Solids digestion, however, does not completely eliminate these materials, so periodic removal of accumulated solids must be accomplished. Depending on the construction and location of these units, this can be a difficult and offensive operation. Clogging of the soil absorption system is the usual result of system failure. The best available compilation of septic tank-soil absorption information and design and maintenance data is the Public Health Service Publication No. 526, Manual of Septic Tank Practice. Septic tank-soil absorption systems vary in cost according to a number of variables. Septic tank purchase and installation cost is reported to be about $400, while the cost of soil systems vary widely. Maintenance costs for septic tank cleaning every 2 to 4 years are estimated at $14/year. Some approximate installation costs for absorption fields based on soil types are (5):

FIGURE 5

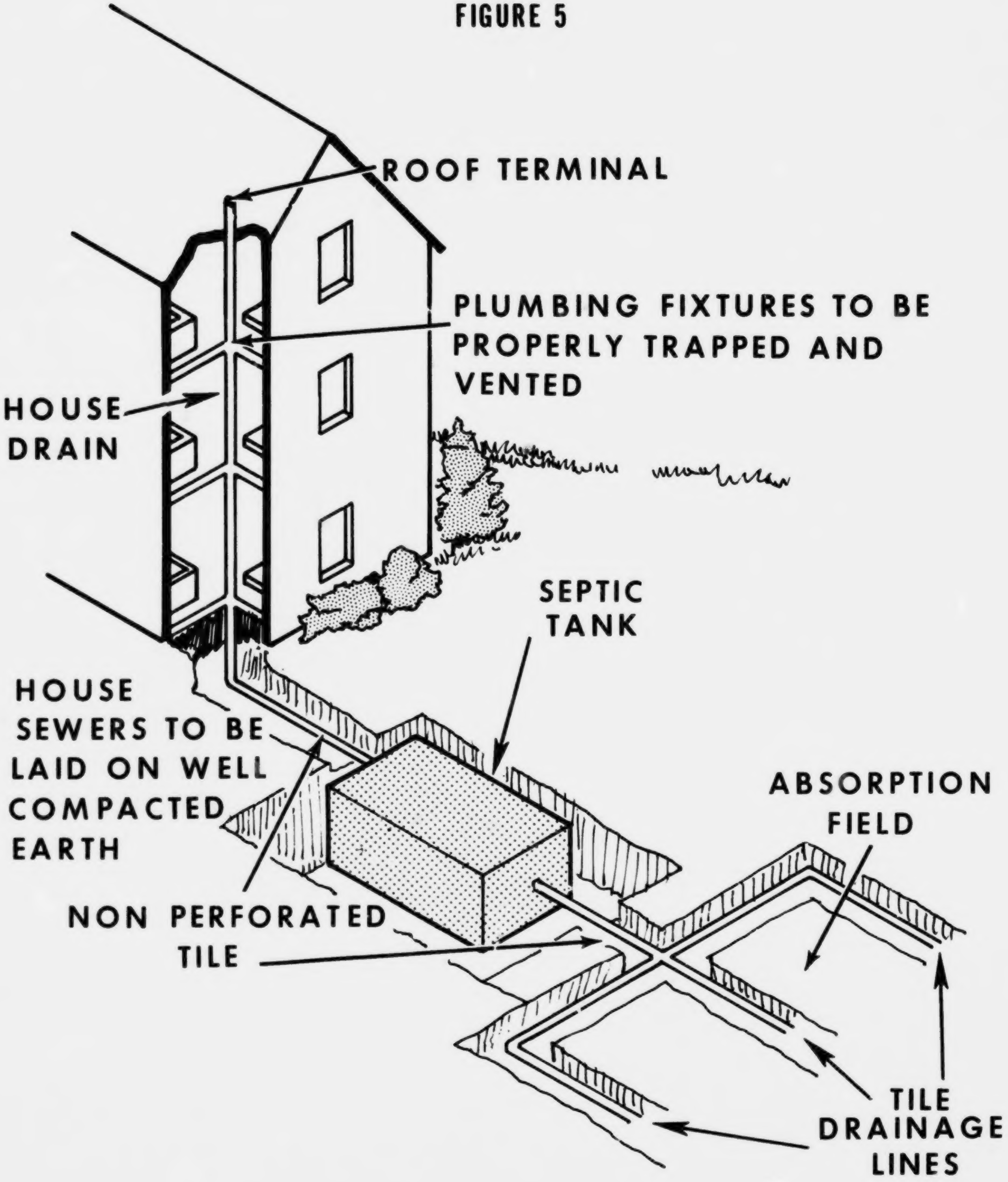
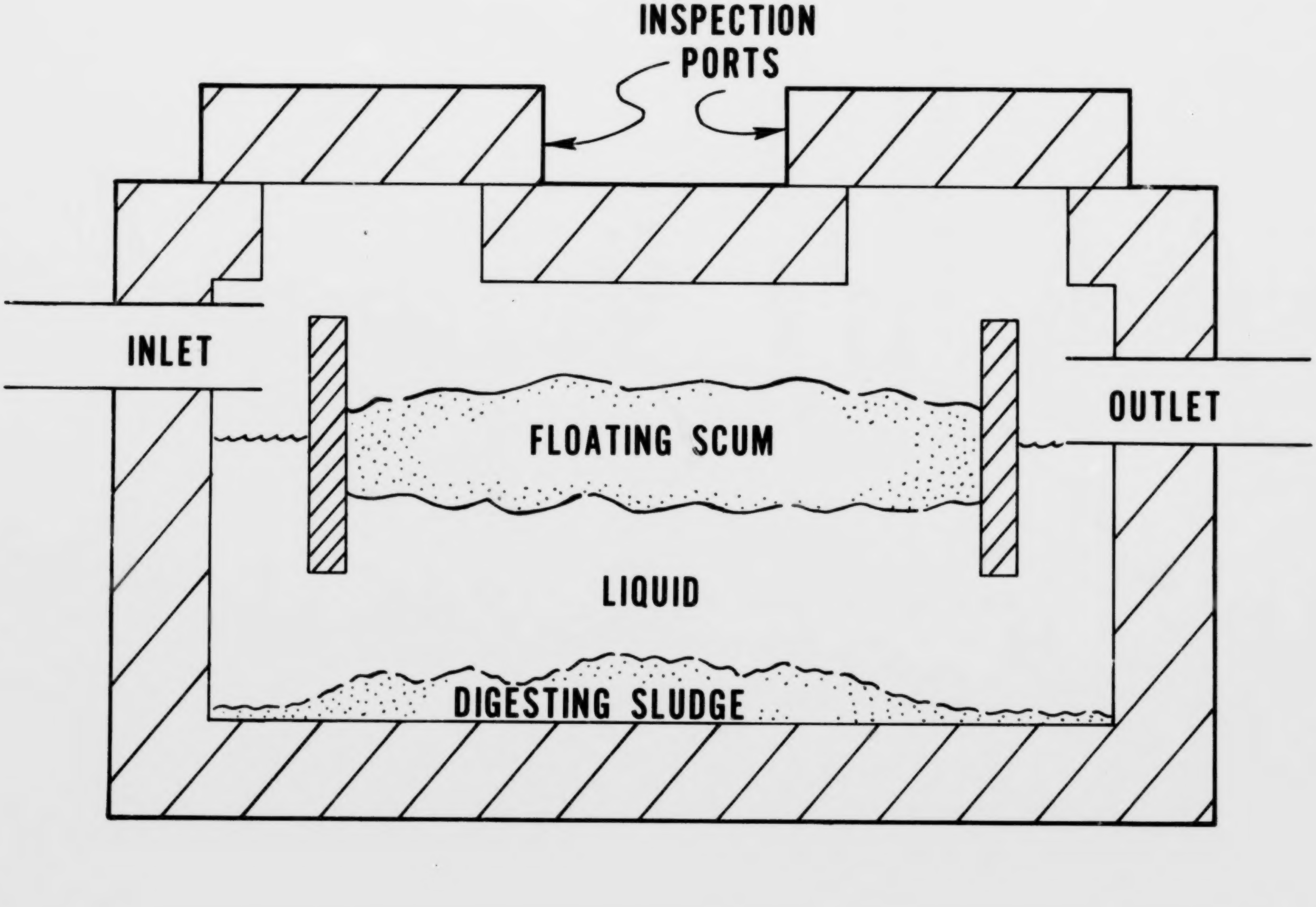
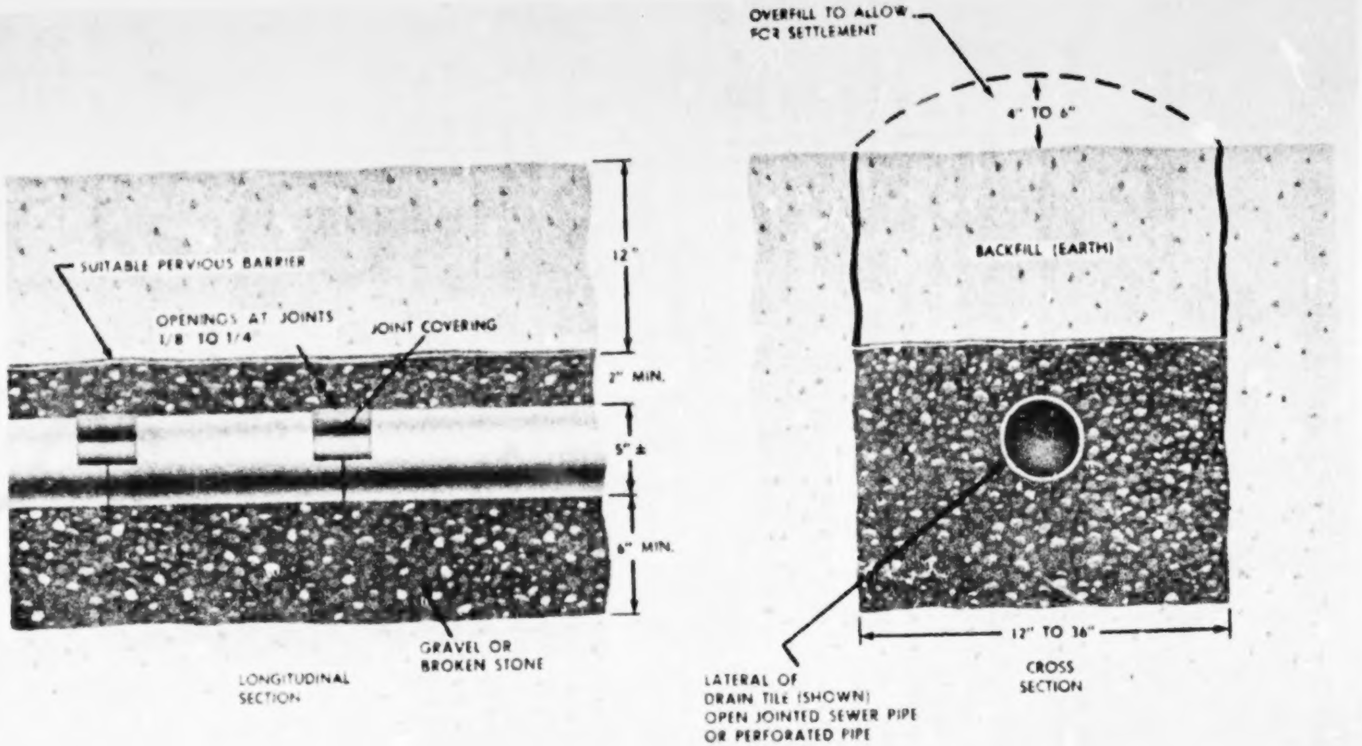

ROOF TERMINAL
PLUMBING FIXTURES TO BE PROPERLY TRAPPED AND VENTED
HOUSE DRAIN
SEPTIC TANK
HOUSE SEWERS TO BE LAID ON WELL COMPACTED EARTH
ABSORPTION FIELD
NON PERFORATED TILE
TILE DRAINAGE LINES

FIGURE 6


INSPECTION PORTS
INLET
OUTLET
FLOATING SCUM
LIQUID
DIGESTING SLUDGE



NOTE: DRAIN TILE LAID WITH JOINTS OPENED FROM 1/8 TO 1/4 INCH. SPECIAL COLLARS MAY BE USED IF DESIRED.

FIGURE 7 ABSORPTION TRENCH AND LATERAL

Soil Suitability	Soil System Installation Cost
Good	$200 - 300
Fair	500 - 750
Poor	1600 - 2400

The septic tank is capable of removing about 50 percent of the organics and about 70 percent of the suspended solids present in the raw wastewater.

Aerobic treatment systems for individual homes generally are required to utilize subsurface soil systems. Technically, their product should be capable of meeting municipal effluent quality in terms of solids and organic matter but their susceptibility to shock loads and toxic chemicals combined with an absence of operating personnel usually will require subsurface disposal. Surface disposal requires disinfection and other necessary treatment to meet public health and water quality standards. Widespread opinion suggests that aerobic effluents should allow a significant reduction in the size requirement of the soil disposal field, but insufficient data on this subject have thus far prevented extensive utilization of this theory. Most systems claim results of approximately 90 percent suspended solids removal without the use of filters and disinfection systems on the effluent. Some typical systems are shown in Figures 8 and 9, These systems are necessarily more expensive than the simpler septic tank.

A number of newer systems are being developed by manufacturers based on more sophisticated treatment principles. A definite need exists for treatment systems which can be added to existing septic tank systems to obtain improved performance as well as for systems which can be installed as alternative treatment systems with superior removal capabilities. A study proposed for the near future is designed to determine the necessary reliability of new individual home wastewater treatment systems and to pursue the development of a model code for the regulation of all individual home systems.

Centralized Treatment

Previous discussion has pointed out the difficulty of centralized treatment in rural areas. The major problem of individual household wastewater systems is to dispose of wastewaters in safe manner with minimum hazard to public health (7). With larger contributing sources such as schools, hospitals, resorts, and parks or a small community system, the major problem becomes one of reliable and effective waste treatment. So-called "Package plants" can be utilized for many of these locations because some form of operational manpower can be provided. Such plants have become generally acceptable to most regulatory agencies because of advantages accruing to the ease of enforcement when compared to innumerable small individual systems discharging to surface waters. In light of the previous discussion of potential costs the multiple-dwelling waste disposal system should be broken down into the two phases, collection and treatment. Because of the previously noted cost of providing gravity sewers for sparsely populated areas,

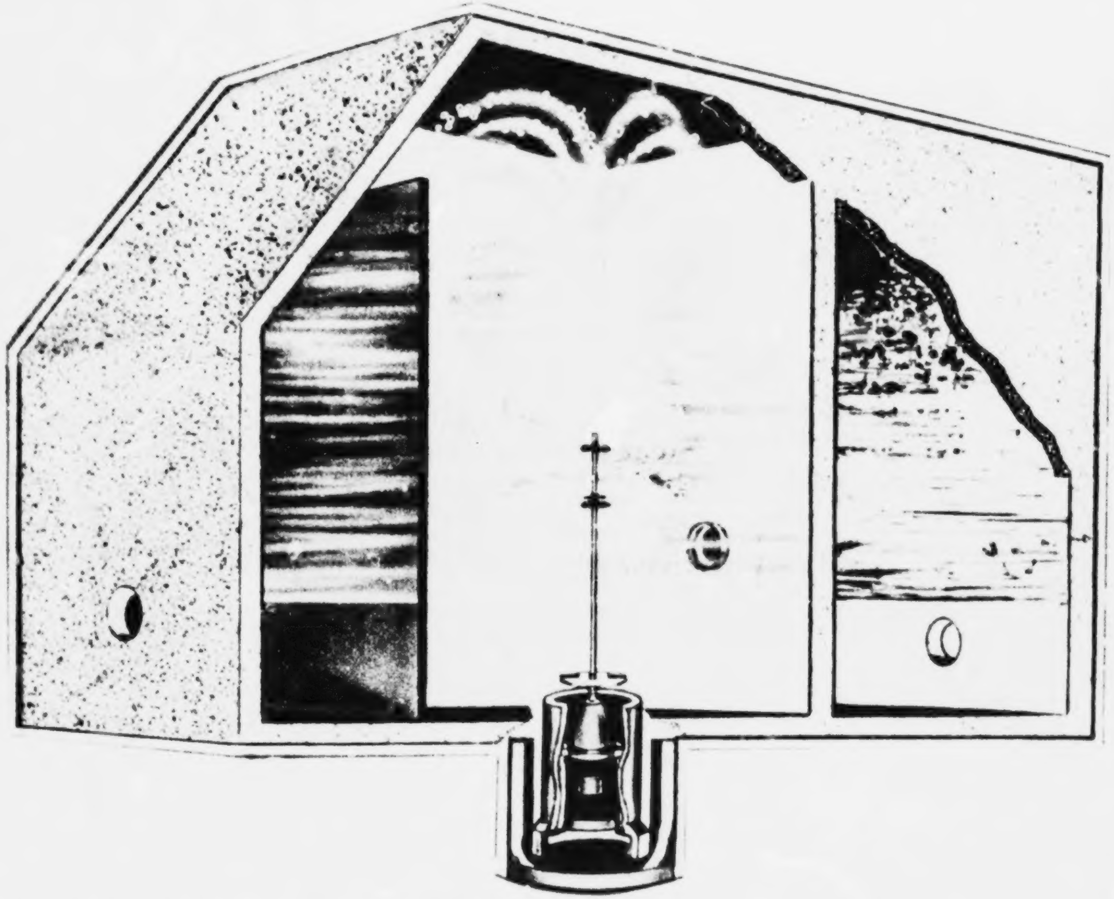


FIGURE 8 TYPICAL INDIVIDUAL HOUSEHOLD AEROBIC SYSTEM

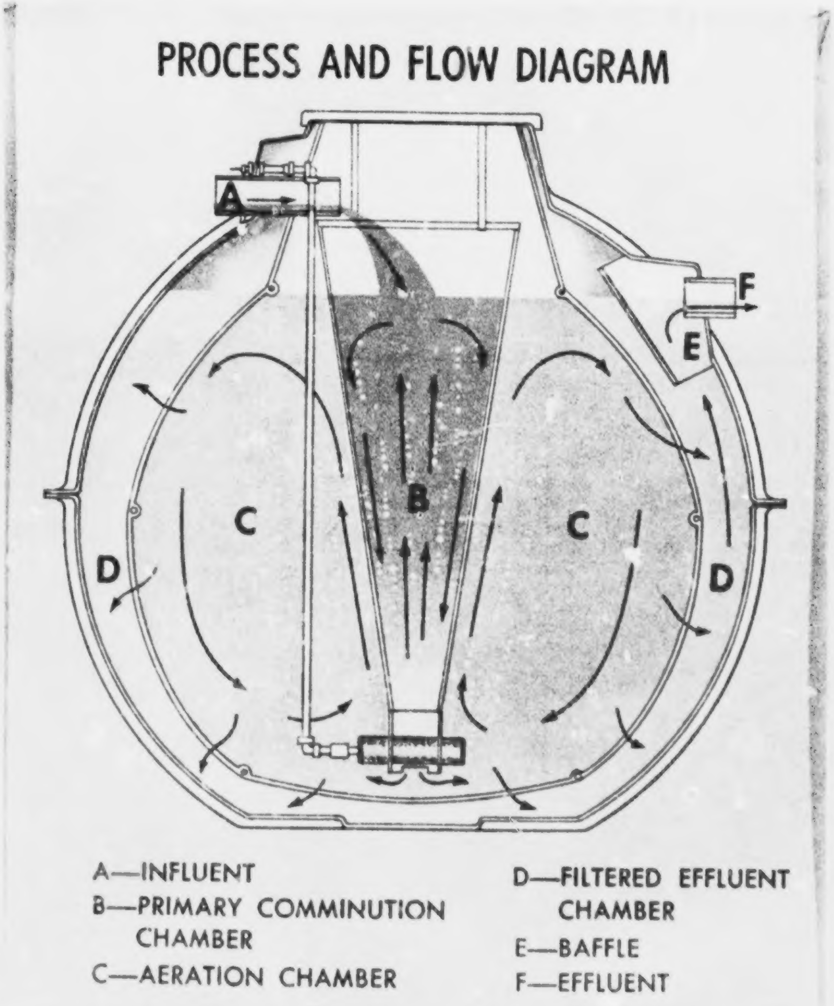


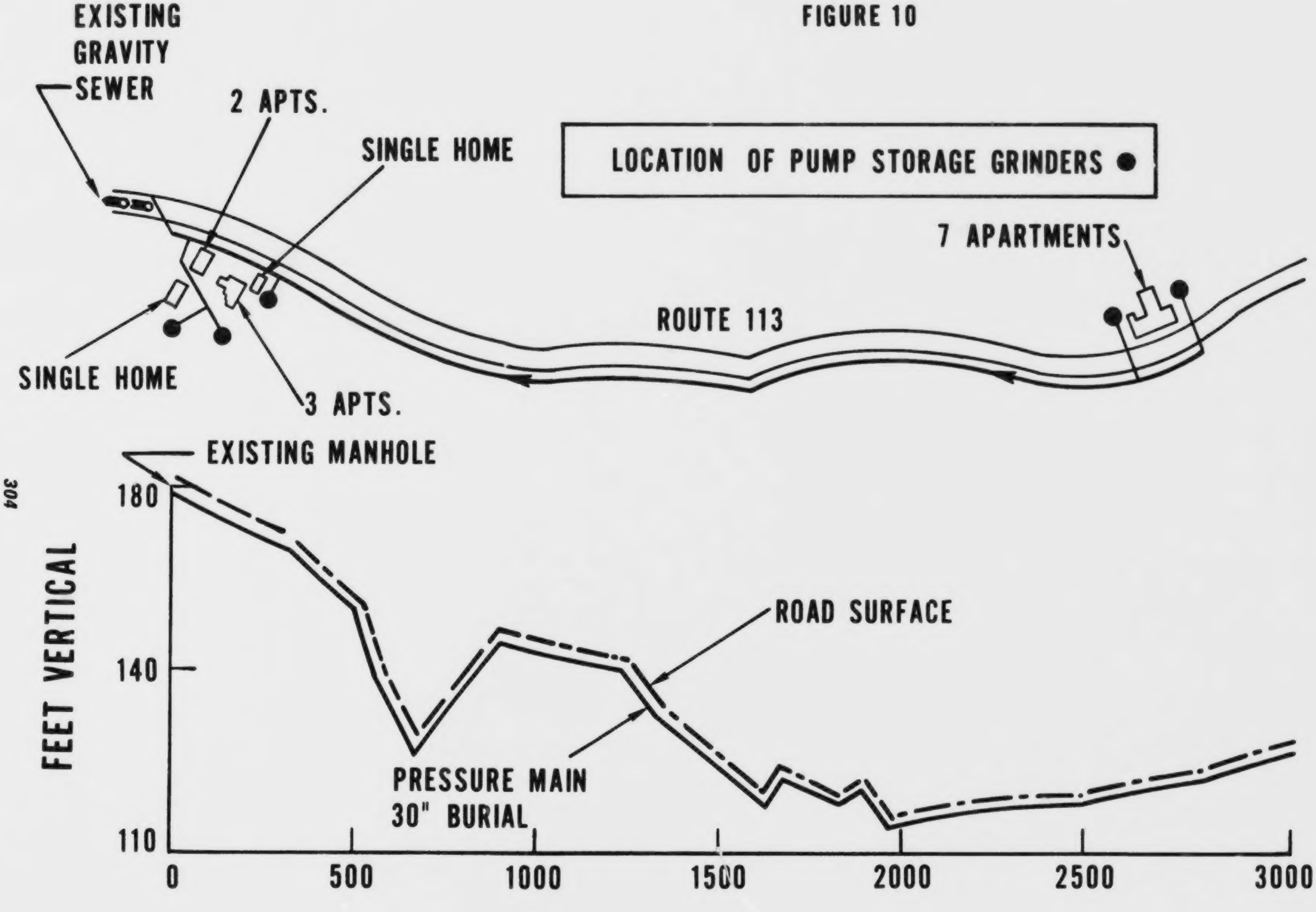
FIGURE 9 TYPICAL INDIVIDUAL HOUSEHOLD AEROBIC SYSTEM

the Environmental Protection Agency has supported two projects on the development of low-cost pressure sewer systems. One of these, Grandview Lake, Indiana, has been reported on at this session. The other is located in Phoenixville, Pennsylvania. The Phoenixville project involves fewer residences, different pump-grinder units, a more difficult terrain and no treatment of the wastes. The system is shown schematically in Figure 10.
Ground sewage is pumped through 1-1/2 and 2-inch-diameter PVC lines at an average flow of 11 gpm under pressures of up to 50 psi. The pump-grinder units shown in Figures 11 and 12 are rated to pump a minimum of 8 gpm into a 60 psi system and a maximum of 15 gpm at atmospheric pressure. Emergency bypasses to septic tanks are provided at the pump-grinder units in case of a malfunction. The collection pipe was laid at a depth of 30 inches which is below the frost line. In the Phoenixville situation the low elevation and high water table made conventional sewers prohibitive and individual home systems impractical. Evaluation of this system is due for completion before the end of the year.

A vacuum collection system has also been considered because of its associated water-savings potential. This system has been withdrawn from the market at this time due to some mechanical difficulties, but it is expected to return in the near future. If pressure and/or vacuum systems prove successful, many problems associated with individual home treatment may be alleviated. Possibly the most difficult problem is the fact that more than one-half of the land area of the United States is not suitable for disposal of wastewater. Where feasible, centralized collection and treatment with surface discharge may open up much of this land for development or, at least, reduce required lot sizes to increase the tax base of the area. The other difficulties of soil-clogging, predicting infiltration rates, septic-tank cleaning, and public health problems could be eliminated in many areas. It is relatively assured that centralized treatment will become economically feasible for significantly greater numbers of homes as a result of these developments. Once economic data on these systems are available, the engineering evaluation of the relative economics of centralized treatment and collection systems versus individual home treatment and disposal systems becomes a relatively straightforward computation if both systems are deemed feasible for implementation. Superimposed on any such evaluation will still be the socio-economic, political, and other superseding considerations, but these ultimate decisions will be made easier with more precise information on the engineering alternatives.

Treatment of the larger wastewater flows is usually accomplished by package plants based on biological treatment principles. Although most are some form of an activated sludge or dispersed-growth system, there are also systems based on a fixed-growth or trickling filter design. Numerous varieties of these plants are offered by a large number of manufacturers, but most are either extended aeration or contact stabilization systems as illustrated in Figures 13 and 14, respectively. In some instances where toxic compounds are found in the waste, space limitations exist, or extreme flow variations occur, biological systems are not capable of providing proper treatment (3). In these cases, some form of physical-chemical treatment may be required in place of a conventional biological unit. These systems have the advantage of being able to operate on an on-off mode without a significant degradation in effluent quality. Phosphorus removal is also inherent in most designs, so that effluent phosphorus standards can be met where required.

FIGURE 10



PROFILE

FIGURE 11

FIGURE 12

FIGURE 13

EXTENDED AERATION

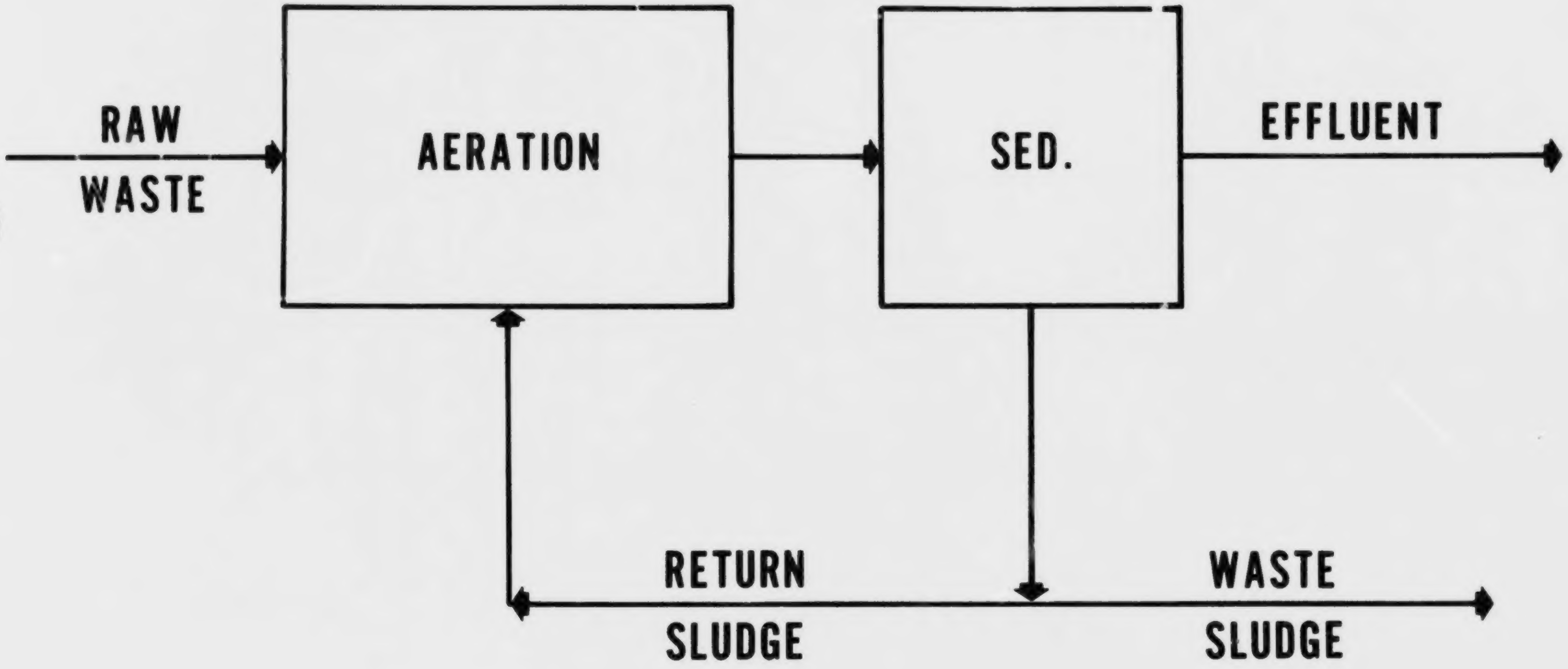
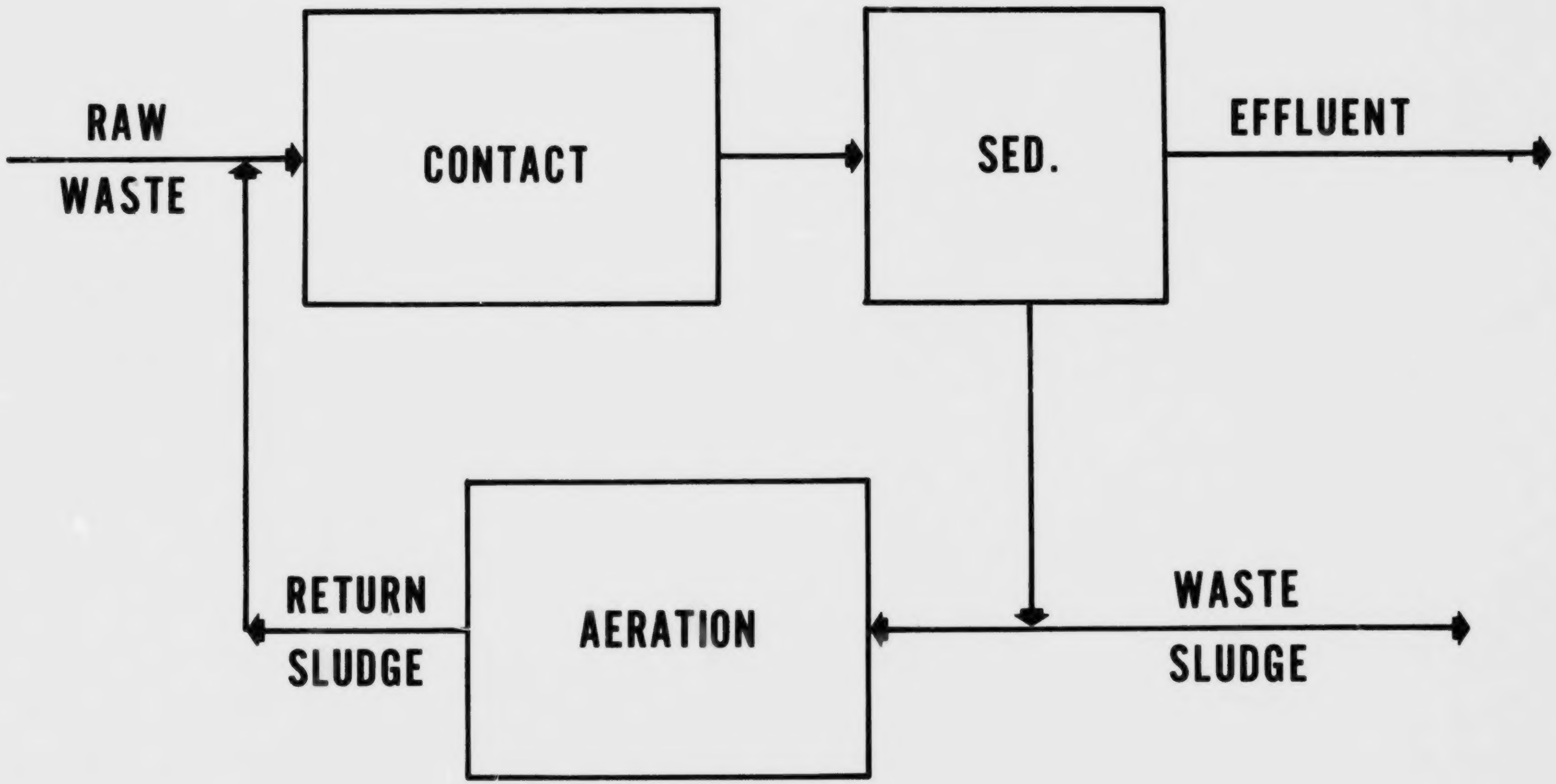


FIGURE 14

CONTACT STABILIZATION



The Environmental Protection Agency is pursuing development of physical-chemical systems in order to be able to meet the needs of locations where biological treatment is inadequate.

The EPA program in the area of small systems or individual home wastewater treatment has thus far been concerned with the development of low-cost collection systems as well as the development of a state-of-the-art survey of flow reduction and wastewater treatment for individual homes. Projects in the near future are concerned with evaluation of household waste treatment systems and the development of model codes and reliability requirements for those systems. Attempts will be made on a continuous basis to utilize advances in processing and control techniques from larger systems for the development of improved methods for the treatment of household wastewaters.

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AGENDA

SECOND U.S.-JAPAN CONFERENCE ON SEWAGE TREATMENT TECHNOLOGY

DECEMBER 4-6, 1972
WASHINGTON, D.C.

Monday, December 4

10:00 Opening Ceremony

1. Welcome by Mr. Fitzhugh Green, Associate Administrator for International Activities
2. Remarks by Dr. T. Kubo, Head, Japanese Delegation
3. Introduction of Delegates and Confirmation of Agenda - Mr. R. C. Palange, Deputy Head, U.S. Delegation
4. Summary of Cincinnati Conference - Dr. T. Kubo, Mr. F. M. Middleton

10:30 Break

10:50 Papers by Japanese Side

Development of Sewage Works in the Past Ten Years
Comprehensive Basin Planning
Progress and Plans for Sewage Works in Japan
Establishment of Japan Sewage Works Corporation -
  Dr. T. Kubo
Financing of Sewage Works in Japan - Mr. T. Matsumoto
  Presentation - 15 minutes
  Discussion - 10 minutes

12:00 Luncheon: Host, National Clay Pipe Institute

1:30 Papers by Japanese Side

Establishment of Environmental Water Quality
  Standards and Countermeasures - Mr. K. Yamamura
An example of Fighting Industrial Waste Pollution
  in Yokohama - Mr. M. Sato
Sludge Treatment and Disposal in Tokyo - Mr. F. Hongo

3:10 Break

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3:30	Industrial Waste Treatment Technology in Japan - Mr. K. Hanada Status of Research Program on Sewage Treatment Technology in Japan - Dr. M. Kashiwaya
5:00	Break
6:30	Reception: Host, U. S. Delegation
8:30	Break

Tuesday, December 5

9:00	Mission of EPA Office of Air and Water Programs - Dr. R. L. Sansom, Assistant Administrator
9:30	Impact of Federal Water Pollution Control Act Amendments of 1972 on Wastewater Treatment Plant Financing, Design, and Construction - Mr. R. C. Palange
10:10	Break
10:30	Preparation of EPA Regulations and Guidelines - Mr. L. H. Clark
11:00	Water Pollution Control Federation Viewpoint on EPA Regulations and Guidelines - Mr. R. A. Canham
11:30	Use of New Technology in Wastewater Treatment Plant Design - Mr. R. S. Madancy
12:00	Luncheon: Host, Consulting Engineers Council of the United States
1:30	Water Quality Management, Planning - Mr. M. A. Pisano
2:00	Design Guidelines for Municipal Wastewater Treatment Works - Mr. C. L. Swanson
2:30	Operation and Maintenance Guidelines for Municipal Wastewater Treatment Works - Mr. W. G. Gilbert
3:00	Break
3:20	Guidelines for Joint Treatment of Municipal and Industrial Wastes - Mr. C. H. Sutfin
4:00	Industrial Waste Effluent Guidelines - Mr. Allen Cywin

5:00	Break
6:30	Reception: Host, Japanese Delegation
8:30	Break

Wednesday, December 6

9:00 - 11:00	Industrial Waste Treatment Technology - Mr. Allen Cywin and Mr. W. J. Lacy
9:00	Metal and Metal Products - Mr. E. Dulaney
9:15	Chemicals - Mr. G. Rey
9:30	Discussion - Mr. A. Cywin
9:50	Break
10:10	Textiles - Mr. C. H. Ris
10:25	Food Processing - Mr. H. G. Keeler
10:40	Discussion - Mr. W. J. Lacy
11:00	Official Closing of Conference
	1. Joint Communique - Dr. R. L. Sansom
	2. Address of Thanks - Dr. T. Kubo
	3. Conference Closing - Mr. Fitzhugh Green
12:00	Luncheon: Host, U. S. Delegation
1:30	Press Conference
2:00	Field Trip - Blue Plains Water Pollution Control Plant and Pilot Plant Facilities
6:00	Break
7:00	Reception: Host, Water and Wastewater Equipment Manufacturers' Association
8:30	Break

MISSION OF THE ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR AND WATER PROGRAMS

by

ROBERT L. SANSOM*

Environmental quality emerged as a major national issue in the United States in the late 1960's. As the public became more aware of pollution and its attendant environmentally degrading problems, positive protective actions were demanded with increasing periodicity.

To respond to these demands, legislation was enacted by both the State and Federal Governments to enforce abatement of pollution, to identify the causes and extent of various pollutants and to develop means to treat or control the sources and thus restrict their effects. Initially, the pollution problem was attacked on a piecemeal basis with various governmental units charged with the independent control of specific types of pollutants.

On July 9, 1970, President Nixon sent to the Congress a reorganization plan removing 15 units from existing governmental departments and agencies and relocating them in a new independent agency. When the reorganization plan became effective on

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* Assistant Administrator for Air and Water Programs, Environmental Protection Agency, Washington, D. C. 20460.

Presented to the Second U.S.-Japan Conference on Sewage Treatment Technology, December 5, 1972.

December 2, 1970, the United States Environmental Protection Agency became operational and was charged with controlling air and water pollution, drinking water quality, solid wastes, pesticides, environmental radiation, and noise. Its principal mission is to enhance and protect the environment.

The Environmental Protection Agency is responsible for conducting research and demonstrations to develop new and better technologies for pollution control, for establishing and enforcing standards and regulations, for monitoring environmental pollution and quality, and for assisting State and local governments in their efforts to ensure a cleaner environment. The EPA was organized with five assistant administrators with individual responsibilities in administration; research and monitoring; enforcement and general counsel; pesticides, radiation, solid wastes, and noise; and air and water programs. Program efforts are directed toward problem solving through ten regional offices, each of which encompass a geographic portion of the United States. Currently there are about 8,000 employees assigned to the Washington headquarters, to the ten regional offices, and to 31 associated laboratories located in 19 States.

The Office of Air and Water Programs is responsible for program policy development and evaluation for the development and promulgation of environmental criteria and pollution source effluent standards, for technical and financial assistance to States and other entities to further pollution control efforts, and for the technical direction of regional pollution control activities.

Organizationally the staff of the Office of Air and Water Programs is administered by Deputy Assistant Administrators for stationery air sources pollution control, mobile air sources pollution control, water programs operations and water planning and standards. The staff further is divided into a number of Divisions that address particular aspects of the air and water pollution control program. The theme of this conference is sewage treatment technology and the Divisions within the water pollution control program include Municipal Waste Water Systems, Oil and Hazardous Materials, Water Supply, Water Quality and Non-Point Source Control, Effluent Guidelines, Monitoring and Data Support and Water Planning. You will be hearing from a number of the water Division Directors and their associates throughout the course of the day as they discuss the development of guidelines for a number of different purposes associated with sewage and industrial wastes treatment technology.

The principal piece of legislation to protect United States air quality was the Clean Air Act Amendments of 1970. Under their provisions:

(1) EPA is authorized to promulgate ambient air standards specifying the maximal levels to be permitted in the ambient air for a particular pollutant. Two types of standards are established: primary and secondary. The primary standards are to protect the public health and the secondary standards are to prevent other undesirable effects of pollution such as damages to crops, vegetation, wildlife, and property. Air quality standards were promulgated in April, 1971, for six pollutants: sulfur oxides, particulate matter, carbon monoxide, hydrocarbons, nitrogen oxides, and oxidants, together with standard reference methods for their measurement.

(2) EPA establishes and enforces performance standards (emission standards) limiting emissions from new or modified stationary sources of pollutants. To date new source performance standards have been promulgated for fossil-fuel fired steam generators (over 250 million B.t.u. per hour heat input), incinerators, cement plants, nitric acid plants and sulfuric acid plants.

(3) EPA establishes and enforces federal emission standards for pollutants that, while not necessarily widespread, are exceptionally hazardous to human health. Standards have been proposed for beryllium asbestos and mercury.

(4) EPA establishes and enforces emission standards for new motor vehicles. The most restrictive standards promulgated to date require a reduction in hydrocarbons and carbon monoxide emitted by 1975 models of 90 percent compared with the 1970 requirements, and a 90 percent reduction in oxides of nitrogen by 1976 models compared with 1971 emissions.

(5) States must develop and carry out approved implementation plans for limiting the emission of pollutants to achieve the primary standards within three years (by 1975), and to achieve the secondary standards within a reasonable period of time thereafter. If any State should fail to develop or carry out such plans, EPA is authorized to do so.

(6) EPA may regulate or prohibit the manufacture or sale of fuels or fuel additives that result in harmful emissions or interfere with motor vehicle pollution control devices. Regulations limiting the levels of lead and phosphorous additives in gasoline have been proposed and are now open for comment.

(7) EPA conducts extensive research into all aspects of air pollution, both in its own laboratories and through grants and contracts. It constructs and operates demonstration plants or processes, or financially assists such projects. Research efforts are supported and incentives are provided to private industry for

the early development of low-pollution motor vehicle propulsion systems.

(8) Financial grants are made to State, interstate, and local agencies to aid their air pollution control programs.

(9) EPA is required to study the impact of aircraft emissions on air quality and determine the feasibility of controlling these emissions.

(10) Public hearings are required at various steps in the standards-setting, enforcement, and regulatory procedures to enable all interested persons to comment. Private citizens are specifically authorized to take civil court action against private or governmental officials failing to carry out the provisions of the law.

The control of water pollution in the United States will be impacted significantly by two very recent legislative actions: The Federal Water Pollution Control Act Amendments of 1972 and the Marine Protection, Research and Sanctuaries Act of 1972. The former legislative package is a very comprehensive and complex law that addresses all types of water pollution, whereas the latter package addresses the problems associated with ocean dumping.

The national goal as specified in the Water Pollution Control Act Amendments is that the discharge of pollutants into navigable waters be eliminated by 1985 and that wherever attainable an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983. Further, the national policy is that the discharge of toxic pollutants in toxic amounts be prohibited.

The Office of Air and Water Programs has a number of major responsibilities under this recently enacted law. Mr. Palange will soon discuss these new mandates as they affect the distribution of Federal monies for waste treatment facilities. The amounts of money authorized for waste treatment plant construction (up to $18 billion) are substantially in excess of any similar Federal authorizations in the past.

We are mandated to develop effluent limitations for point source pollutional wastes and to promulgate national standards of performance for new source wastes that will include a minimum of 27 industrial waste categories. We must publish a list of toxic pollutants or any combination of such pollutants and propose effluent standards which shall take into account their toxicity, persistence, and degradability.

The Office of Air and Water Programs must develop a criteria to define dredge spoils that would be acceptable for introduction into the water environment. It must also develop criteria to define those materials and their quantity and quality that are acceptable for discharge or dumping into the oceanic environment.

We are mandated to publish guidelines for identifying and evaluating the nature and extent of non-point sources of pollutants and to develop processes, procedures, and methods to control pollution resulting from agricultural and silvicultural activities, mining activities, construction activities, disposal of pollutants into the subsurface environment, and salt water intrusion.

The Water Quality Improvement Act of 1970 provided for the promulgation of standards of performance to control the discharge of human body wastes from vessels. These were published in June 1972 and provided for a no discharge of sewage overboard from such vessels.

Because of these many activities mandated by recent law and because of the very short deadlines that have been provided for their implementation, we look forward to this type of international conference where we can exchange ideas and meaningful dialogue with those of you who have been attempting to solve these problems in other geographic areas. We have much information to gather before we will be able to manage the environment in the best interests of all of its inhabitants.

Discussions such as these in which we are engaged during this three-day period should add materially to this fund of mutual knowledge and should be beneficial to all participants. I trust and expect that our formal presentations and informal comments will prove beneficial to both governments in furthering the causes for pollution control and environmental enhancement.

IMPACT OF FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972 ON WASTEWATER TREATMENT PLANT FINANCING, DESIGN, AND CONSTRUCTION

By

Ralph C. Palange
Charles L. Swanson
Charles H. Sutfin

Office of Water Programs Operations
Environmental Protection Agency
Washington, D. C. 20460

December 1972

IMPACT OF FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972 ON WASTEWATER TREATMENT PLANT FINANCING, DESIGN, AND CONSTRUCTION[1]

By

Ralph C. Palange[2]
Charles L. Swanson[3]
Charles H. Sutfin[3]

Introduction

The Federal Water Pollution Control Act Amendments of 1972 were enacted on October 18, 1972 and authorize an appropriation of $18 billion in Federal funds for construction of wastewater treatment works to help restore and maintain the chemical, physical and biological integrity of the Nation's waters.

On the surface, it would appear that the Environmental Protection Agency's job is a very simple one involving only the disbursement of funds to municipalities. However, coupled with the grant program is the EPA responsibility to insure that treatment works constructed with Federal financial assistance conform to an overall basin or regional water quality management plan, incorporate the best practicable technology, are cost-effective, and are adequately operated and maintained. Incorporated in the legislation are the necessary requirements to ensure that these goals are met.

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[1] Prepared for Second U.S.-Japan Conference on Sewage Treatment Technology, December 4-6, 1972, Washington, D. C.

[2] Engineering Advisor, Office of the Deputy Assistant Administrator for Water Programs Operations, Environmental Protection Agency, Washington, D. C. 20460

[3] Chief and Deputy Chief, Respectively, Engineering and Design Branch, Municipal Waste Water Systems Division, Office of Water Programs Operations, Environmental Protection Agency, Washington, D. C. 20460.

Financial

The backbone of EPA's water pollution control effort is the program for granting Federal financial assistance to municipalities for construction of wastewater treatment works. This program, since its initiation in 1956, has provided over $3 billion for some 12,000 facilities having a total construction cost of over $12 billion. At the present time approximately 2500 projects are under construction with a total cost of $7 billion. The majority of these projects are being funded from FY-70 or later appropriations. The legislation will increase maximum funding levels from the current appropriation of $1.65 billion for FY-72 to a maximum authorization of $5 billion for FY-73, $6 billion for FY-74, and $7 billion for FY-75. The Federal share will be increased from the previous maximum of 55 percent to 75 percent.

Required Regulations and Guidelines

Implementation of the legislation will have a major impact on treatment plant financing, design, and construction. In the near future, EPA will issue new regulations and guidelines in many subject areas. Some specific areas that will be of interest and the time schedules for completion following the date of enactment of the legislation include:

	Time-Days*
Definition of Secondary Treatment	60
Infiltration/Inflow Studies and Control	120
Industrial Waste Pretreatment Guidelines	120
Industrial Waste Pretreatment Standards	180
User Charges	180
Cost-Effectiveness Studies	180
Definition of Best Practicable Technology	270

*From October 18, 1972 enactment

An accelerated program is now underway to develop these regulations and guidelines by the EPA staff and by the use of outside contracts. The major portion of the work is being conducted under contract with architect/engineer firms. Several studies were initiated by July 1972 in anticipation of passage of the legislation, and results are now available for internal and external review.

EPA preparation of regulations and guidelines involves participation of the major organizations concerned with water pollution control. Proposed documents are reviewed by a 12-member Technical Advisory Group, State Administrators, EPA Regional Offices, and committees at EPA Headquarters.

It is essential that the current construction program be continued during development of the detailed requirements. Therefore, the new legislation provides that all rules, regulations, and other requirements in effect prior to the effective date of the new legislation will remain in effect until modified or rescinded in accordance with the new regulations and requirements. A brief description of these tasks is given below.

Secondary Treatment Definition

The legislation requires that information on the degree of effluent reduction attainable by the application of secondary treatment to municipal wastewaters be published by EPA. Effluent limitations based on this published information must be achieved by all publicly owned treatment works in existence on July 1, 1977 or approved for construction grants prior to June 30, 1974.

This study was initiated by contract in August 1972 and has now been completed. It consisted of a literature review and survey of operating data from approximately 80 well-operated "secondary" treatment plants. Results will be published in the Federal Register for comment in mid-December. Following a period for public comment, the regulation will be promulgated. This definition will supersede the July 1971 Regulations which required 85 percent removal of BOD and substantial removal of suspended solids and pathogens.

Infiltration/Inflow Studies

The legislation requires that no grant be approved after July 1, 1973 unless the applicant shows to the satisfaction of the Administrator that the sewer system is not subject to excessive infiltration. Costs for sewer system evaluation surveys and rehabilitation are also eligible for grant participation.

A proposed regulation on sewer system infiltration/inflow has been prepared for publication in the Federal Register. The purpose of the regulation is twofold: To prevent excessive TV or other inspections of sewer systems and to require that system rehabilitation be conducted on a cost-effective basis. Basically, the new regulation will require that:

1. An analysis to determine if infiltration/inflow is or is not occurring must be included in the preliminary engineering report.

2. In cost-effectiveness studies, the same level of treatment must be considered for the alternative of not rehabilitating the system.

3. Plans for sewer system evaluation surveys must be submitted to EPA for review and approval.

4. A city ordinance must be enacted that will prohibit inflow connections for all new construction. Inflow will generally include waters from foundation drains, downspouts, and other drains that do not normally require treatment.

The preliminary analysis should identify the presence, quantity, and type of infiltration/inflow conditions which exist in the sewer system. This analysis should include examination of flow records, relationship of existing and future population and industrial loads to flow, location and cause of present overflows, and the present condition of sewers.

A sewer system evaluation survey is defined as a systematic examination to determine the location, flow rate, and cost of correction for each element of the problem. Problem areas in the system should be isolated prior to TV or other inspection. The survey report should outline a program for joint sealing and other system rehabilitation on a selective cost-effective basis.

Pretreatment Guidelines and Standards

The legislation requires that industrial waste pretreatment guidelines be published within 120 days.

The stated goal in the Act is to prevent the discharge of pollutants to municipal systems which would interfere with treatment, pass through inadequately treated, or be otherwise incompatible with municipal sewers or treatment facilities.

The Act also requires that pretreatment standards be published for comment 180 days after enactment and promulgated within 270 days, with the time for compliance not to exceed three years. Where State or local requirements are more stringent than the Federal standards, the State and local requirements will govern.

The pretreatment guidelines will in most cases specify unit operations such as flow equalization, chemical treatment, and solids removal, rather than dealing in specific quantities or levels of pollutants. However, municipal permits will reflect pretreatment required of industry in terms of wastewater quantity and quality. Municipal permit pretreatment requirements will be directly enforceable on industry by EPA. Draft guidelines and regulations have been prepared and are now being reviewed.

Detailed pretreatment requirements will be given for 24 specific industrial categories, in which specific pretreatment unit processes will be indicated. These unit processes will be required for removal of pollutants which would be either harmful to or otherwise not amenable to treatment in a joint treatment system. Guidelines will be provided for three types of "secondary" joint treatment processes --- activated sludge, trickling filters and independent physical/chemical.

There will be no pretreatment requirements for pollutants which would be compatible with the joint treatment process. This would be decided on a case-by-case basis, depending on the design capacity and capabilities of the joint treatment facility. In some cases it would prove more economical to pretreat compatible pollutants because of concentration effects.

User Charges

The Act requires that guidelines and regulations for recovery of industry's share of treatment costs be published within 180 days. The "Federal Guidelines - Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems," which were issued in October, 1971 are being revised to incorporate requirements of the new Act.

The new legislation requires recovery of the grant portion from industrial users through a system of user charges, including both capital costs and operating and maintenance costs. The Act provides that each grant applicant shall retain an amount of the revenues derived from the repayment of cost by industrial users, to the extent such costs are attributable to the Federal share of the project costs, equal to the sum of (A) the amount of the non-Federal cost of the project, paid by the grantee, and (B) the amount necessary for future expansion and reconstruction of the project, except that such retained amount shall not exceed 50% of such revenues from such project. The funds retained by the grantee attributable to "future expansion and reconstruction" must be used solely for such purposes. All revenues not retained by the grantee are to be deposited in the U.S. Treasury as miscellaneous Federal receipts.

The guidelines will also include: (a) provision for the establishment of classes of users, including categories of users; (b) criteria for determining the adequacy of imposed charges; and (c) model systems and rates of user charges typical of various treatment works.

The guidelines must reflect varying legal and financial factors which exist in different jurisdictions. For industrial user charges they must also reflect, as a minimum, such factors as strength, volume, and flow characteristics of the waste.

Cost-Effectiveness Guidelines

The legislation requires that cost-effectiveness guidelines on basin planning and process selection and design be published within 180 days. A cost-effective treatment system is defined as a combination of unit processes, selected to produce a specific level of treatment, which will result in the least total cost to the public, regardless of the sources of the funds used to finance the project.

Information previously published by EPA will be refined to develop more comprehensive guidelines on basin and regional planning.

Studies on cost-effectiveness of process design are now being initiated. The first phase of the work will define techniques for selecting the most cost-effective process combinations for the treatment of municipal wastewater to meet the initial requriements of the legislation. The second phase will be conducted at a later date and summarize unit process costs and establish relationships between these costs and efficiency of pollutant removal. When completed, the second phase will be published as a supplement to the initial guidelines.

Best Practicable Technology

Information on alternative waste treatment management techniques and systems available to implement the Act must be published within 9 months of enactment of the legislation. The major emphasis in the initial publication will be on alternative secondary treatment processes, with some reference to best practicable technology. The definition of best practicable technology will be updated from time to time to meet the July 1, 1983 goal.

The secondary treatment definition will serve as a base for definition of best practicable technology. This initial definition may include the capabilities of new treatment techniques.

Summary

In summary, these and other requirements of the legislation will result in the best possible return for the public investment. With full implementation of the Act, we will be initiating the largest waste treatment works construction program in the world. The goals of the new legislation should not be EPA goals alone. They should be the mutual goals of all concerned with protection of our Nation's waters.

We expect to achieve the goals through a coordinated effort with State agencies, municipalities, design engineers, and industry. Such a partnership is essential to achievement of our goals.

THE PREPARATION OF EPA REGULATIONS AND GUIDELINES

LYMAN H. CLARK

Director, Cost and Economic Impact
Analysis Branch
U.S. Environmental Protection Agency

December 5, 1972
Second U.S. Japan Conference
on Sewage Treatment Technology

I have been asked to speak to you about the Environmental Protection Agency's procedures for developing regulations and guidelines. This afternoon you will hear from the men who are actually responsible for developing the guidelines required by the Federal Water Pollution Control Act. They, I assume, will explain the technical considerations that will be part of their guideline development process. I will devote my time this morning, therefore, to the procedural aspects of guideline development.

Developing standards for pollution abatement and control is one of EPA's most important functions. In this effort, originating EPA offices (generally program offices) have the primary responsibility for developing appropriate standards and providing documentation to support them. The Agency's procedures for developing these items are set forth in Order 1000.6 entitled, "Policy and Procedures for the Standards and Regulations Development Process." For your information, I have attached a copy of Order 1000.6 to the transcripts of my speech today.

BACKGROUND

Prior to Order 1000.6, originating offices took sole charge of developing and preparing rule-making activities. Other offices within the Agency reviewed them only when Assistant Administrators of the originating offices sent memorandums to the other Assistant Administrators seeking their concurrence in forwarding the rule-making activities to the Administrator, for his approval. This system simply did not work well for three basic reasons:

1. Originating offices seldom sought the expertise of other EPA elements in specialized areas outside their own domain. Developing offices, for example, almost never obtained technical or cost-benefit analysis from experts in these fields in other offices of the Agency.

2. The Assistant Administrators, and ultimately the Administrator, were presented with one course of action to approve or disapprove rather than being provided with a range of options from which to choose.

3. Assistant Administrators not originally involved in drafting the regulation were afforded little time and no background materials on which to determine to concur or not to concur.

As a result of these shortcomings, the Administrator was compelled to accept or reject a proposed course of action without full knowledge of its implications or the alternatives available.

By July 1972, it had become evident to Mr. Ruckelshaus and Mr. Fri that intra-agency coordination and review of EPA's rule-making activities were necessary before they were sent to the Administrator for approval. To accomplish this, a task force was formed to draft a set of internal procedures to ensure the coordinated development of the Agency's rule-making activities. The culmination of this effort was Standard-Setting Order 1000.6. This Order was signed on December 10, 1971, after extensive revisions and two rounds of circulation to all Assistant Administrators.

STANDARD-SETTING ORDER 1000.6

Order 1000.6 stipulates how EPA's standards, regulations, guidelines, and reports are to be fashioned. It is designed to ensure that due consideration is given to the technical, legal, economic, environmental, and administrative aspects of any standard which EPA establishes. It contains a planning, a development, and an external coordination phase.

A. PLANNING PHASE

The planning phase is triggered by the passage of new legislation or an internal EPA decision to exercise existing authority. The originating office, through a working group, prepares a development plan which specifies a methodology for development, specific time schedules, key milestones for accomplishment, preliminary issues requiring resolution, and key decision points requiring policy guidance from the Administrator. Each Assistant Administrator's office is given an opportunity to review the plan and provide comments. Once outstanding issues are resolved, or stated clearly for the Administrator to resolve, the package is forwarded to the Administrator, through the Assistant Administrator for Planning and Management, for policy guidance and approval.

B. Development Phase

In the development phase, the standards package is actually formulated. During this stage, there are two different levels at which originating offices receive guidance from the rest of the Agency: (1) working groups, and (2) the Steering Committee. The working group provides advice during the development of the standards-package. The Steering Committee reviews a standards package when the originating office considers it ready for presentation to the Administrator. The standards package contains a draft of the proposed rule-making activity and an explanatory "briefing memorandum" for the Administrator. The importance of this "briefing memorandum" cannot be over-emphasized since its contents provide the background information upon which the Administrator bases his decision. Each briefing memorandum must contain a systematic analysis of the need for the proposed standard and its implications, an outline of the alternatives considered, an analysis of the pros and cons of each alternative, and an explanation of the rationale for the course of action chosen.

1. Working Group Consultation

Each working group is chaired by a designee of the office developing the item and includes appropriate representatives of each of the other Assistant Administrators' offices. The goal of the working group is to provide advice and guidance to the office preparing the standards-package during the early stages of its development. At this stage, helpful suggestions which would be more difficult to integrate later can be easily incorporated so that later Steering Committee revisions and resulting developing office rewriting can be kept to a minimum.

When a developing office feels its standards-package has incorporated working group comments to the extent it feels appropriate and that the standards-package is ready in final form for presentation to the Administrator, it sends the package to the Steering Committee for review.

2. Steering Committee Review

Perhaps the most crucial evaluation of the rule-making activity comes from the Steering Committee, because this is the last review the package receives before its presentation to the Administrator for approval. This committee is chaired by the Deputy Assistant Administrator for Planning and Evaluation, and contains at least one representative from each Assistant Administrator's office.

The Steering Committee reviews each proposed standard and its accompanying briefing memorandum and suggests areas where changes are needed before submission to the Administrator. The originating office decides to what extent it wants to incorporate suggestions offered to it. If an office offering a change does not feel its suggestion has been satisfactorily incorporated, it has the right to have its views on this and/or the original change it proposed, made a part of the package which is forwarded to the

Administrator.

The Assistant Administrator for Planning and Management forwards the standards-package to the Administrator with all unresolved issues stated clearly for him to resolve and schedules any necessary briefings with him. After changes proposed by the Administrator are implemented to his satisfaction, the item enters the external coordination phase.

C. EXTERNAL COORDINATION PHASE

After the Administrator's approval, a standard with an appropriately edited briefing memorandum is forwarded to the Office of Management and Budget, the branch of the Executive Office of the President, which coordinates the comments of affected agencies. The Office of Management and Budget circulates the package provided by EPA to affected agencies and schedules a meeting where EPA and the affected agencies can discuss the package directly. After this meeting, any agency so desiring can submit written comments. The originating office must weigh these comments and incorporate them to the extent it believes appropriate. The revised standard is forwarded through the Assistant Administrator for Planning and Management to the Administrator to brief him on EPA's recommended final position. This revised standard must be accompanied by a summary of the major comments and EPA's rationale for accepting or rejecting them. After policy guidance from the Administrator and appropriate communication to the Office of Management and Budget of EPA's final position on the standard, it is finalized by the developing office for publication in the _Federal Register_. The Federal Register is a periodical published by the Federal Government in which all proposed and final rules and regulations must appear.

CONCLUSION

I hope that this presentation has clearly explained to you the Agency's rather complicated procedures for preparing regulations and guidelines. Within the Agency each proposed guideline must go through planning, development, and review stages. Working groups with representatives from all EPA offices are closely involved with the originating office in each of these stages. Finally, the proposed guideline must undergo external review by all other federal agencies. This review is coordinated by the Office of Management and Budget.

"Federation Viewpoint on EPA Regulations and Guidelines"*

Robert A. Canham, Executive Secretary,
Water Pollution Control Federation
Washington, D. C.

It is a distinct privilege for me to participate in this conference with our distinguished visitors from Japan, partly because I have such fond memories of my visits to your country. Also, I note that apparently I am the only American speaker on your week's agenda who does not represent the federal government. It is very flattering and somewhat alarming to find myself in this lonely situation and perhaps I should explain just what the Water Pollution Control Federation is.

WATER POLLUTION CONTROL FEDERATION

Essentially, WPCF is the membership organization for the individuals with careers in the water pollution control field. Our membership is quite diverse, including engineers, biologists, chemists, operators, employed in all segments of the field including operation, design, sales, regulation and administration. Our organization was founded in 1928 primarily for the purpose of communicating up-to-date technical information throughout the field. I am very proud to say that our Journal, which has a subscription of 25,000, is recognized internationally as the foremost published authority on water pollution control. In the past 30 years the Federation has expanded its means of communications to include Manuals of Practice and Annual Conferences, both of which are very well respected. Our Conference this year in Atlanta, attracted a total registration of more than 7,000 individuals, during the week-long presentation of more than 130 technical papers.

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*For presentation to 2nd U. S. Japan Conference on Sewage Treatment Technology

The organization is a federation in that it is made up of some sixty semi-autonomous member associations, 39 of which are in the United States. We are especially proud of affiliations with 21 associations outside the United States, among the foremost of which is the Japan Sewage Works Association, which established a relationship with the Federation in 1966. At the latest count 91 members of the Japan Sewage Works Association are affiliated as members of WPCF. The Federation values its international role and welcomes the growing number of association relationships outside the United States. We were pleased to furnish representation at the UN Conference in Stockholm last year, in the person of our current President, Floyd Byrd, who had "non-governmental observer" status with the U. S. Delegation.

NATIONAL STATEMENT OF POLICY

However, 85% of the WPCF members are within the United States and this means that the Federation also has a national role to play. Our official Statement of Policy on water pollution control was adopted originally in 1960 and has been periodically revised since then. This statement addresses the problems of the United States only and establishes principles which guide the Federation in our efforts to promote action toward the goal of clean water in the United States. Examples from the Statement of Policy which are particularly of interest in our dealings with the federal government are:

Item #4 - "The administration of water pollution control must be firm and effective and should remain in the hands of state and inter-state water pollution control agencies";

Item #5 - "Federal, state and local laws and practices must reflect the changing needs in order to obtain and maintain the most economical and effective means for financing the construction, management, operation and maintenance on wastewater collection systems and treatment works";

Item #8 - "Wastewater represents an increasing fraction of the nation's total water resources and should be reclaimed for beneficial reuse";

Item #9 - "Mandatory certification or licensing of adequately trained and properly compensated personnel must be encouraged as a requirement for maximum effectiveness of treatment facilities."

CHANGING ROLE

There have been cataclysmic changes in the environment which surrounds America's water pollution control program in the last decade. These have quite naturally caused a change in the role of the Water Pollution Control Federation. Since 1965, the American public has become aware of the need for water pollution control as a key element in providing the quality of life that is desired. As a result, the programs of the federal government has grown astronomically to reflect the desires that the citizens have expressed to their elected officials. A key element in the federal role has been the greater ease of obtaining the funds for water pollution control facilities through federal tax dollars rather than through the state and local tax dollars. As water pollution control policy has grown in importance at the national level, the need has grown for the Water Pollution Control Federation to participate.

Accordingly, the national leadership of the Water Pollution Control Federation has prepared and submitted testimony to congressional committees with increasing frequency over the past ten years. Beginning in 1967, the Federation has sponsored annually a one-day government affairs seminar to provide an interface between the technical community and the governmental community at the national level. Each year a particular aspect of the water pollution control situation has been addressed, with a very productive session last year attended by more than 400 registrants to discuss the proposed 1972 federal legislation. In continuation of the Federation's growth in the policy field, paralleling that of the federal government,we will sponsor the first of a series of regional workshops on the massive new federal water pollution control act amendments, a week from today in Detroit. The purpose will be to communicate the tremendously important new elements of the federal law and to discuss the means by which the law will be implemented, and its impact on our programs and goals.

EPA RULES AND REGULATIONS

As the federal role in water pollution control has grown, the importance to the field of federal regulations and guidelines has likewise increased. These federal government regulations affect the technical field and the policy field. Two years ago at our conference in Boston, the Federal Guidelines on Design, Operation and Maintenance were announced. This document established a very powerful framework for the purpose of establishing minimum requirements to be followed by all designers of municipal water pollution control facilities. The reaction from several quarters, including the Federation, was one of grave concern because of the tendency of guidelines to be used as standards. The key to success or failure of course lies in the manner in which they are interpreted.

AUTHORITY

The role and responsibility of the federal government in water pollution is enormous. In large part the degree is related to the amount of monetary subsidy from the government. Beginning with a tiny construction grant program of $50 million in 1955, the federal subsidy to local construction of water pollution control facilities has grown to the difficult-to-comprehend magnitude of $18 billion for fiscal years '73 to '75 (passed over President Nixon's veto in October). Initially the program was aimed at providing an incentive for impoverished rural communities and offered 30% of treatment plant construction cost only. The current program promises 75% of the construction cost of plants and sewers for publicly owned facilities of any size. As might be expected in such a development, by now it is highly doubtful that any local government would meet its responsibility to control water pollution unless the maximum authorized federal grant is provided. Therefore, control of the pursestrings gives the federal government a very powerful role in requiring compliance by the water pollution control field with its requirements.

POLICY

Not only the technical aspects of water pollution control (such as design regulations) are prescribed by the federal government, but also the policy decisions. Examples of this involvement would include decisions at the federal level of the required degree of treatment, acceptable methods of treatment, limits or restrictions on where discharges may be allowed, requirements for coordinated planning in projects, and many other policies.

A basic premise in the federal government's responsibility since it is the largest source of funds for projects is the obligation to ensure the wise spending of these funds. Various methods are included in the law toward that end. One such example is the regulations and guidelines. Basically the regulations establish the terms of requirements for each specific piece of the law. Guidelines explain, amplify in detail, and provide guidance to supplement the regulations. The regulations are formal documents that provide the legal framework for the implementation of the law. Guidelines are explanatory and assist in the understanding of the regulations.

Although the states have been recognized as the primary administrators of the water pollution control regulations, the new legislation passed by Congress over President Nixon's veto may provide some significant alterations in the power distribution. The Environmental Protection Agency is given a much stronger regulatory role than existed previously, unless one considers the broadest interpretation of EPA authority under the 1899 Refuse Act, which never actually reached implementation. The federal law will now require a permit system for all industries and municipalities discharging to America's water resources. The new law provides the opportunity for states to remain on the front line of enforcement but the mechanism exists for the federal government to step in if this responsibility is not adequately discharged.

In addition, the new federal law establishes strong policy goals for America's water pollution control program, including target dates for the use of "best practicable" technology, subsequently "best available" technology, and finally zero discharge of pollutants.

There are many single sections of the new law, such as the one which seeks to correct the problem of excessive infiltration in sewer systems, which will take months and perhaps years to delineate and implement but which can be expected to have important impact on the course of water pollution control practices.

As the federal government moves to provide the details which will give form to the new federal water pollution control program there will be many opportunities for progress but many obstacles to overcome. From the viewpoint of the private sector, there is a danger of overcentralization and too much control in the hands of a few. The caution heard is that this should not cause standards, or regulations, to become too confining, because this could stifle the creativity of the professional designer. In summary, the outlook for water pollution control in the United States in December 1972 is promising but full of challenges.

COLLABORATION

The Water Pollution Control Federation is seeking to meet these challenges. The opportunities to move forward which are now within our grasp have given our people and their careers new purpose and new excitement. We are in the process of learning the new rules of the game, along with our colleagues in the federal government, and we look forward to working together toward the national goals with optimism concerning the outcome. In our opinion, there is a vitally important role for the professional and technician outside the federal government to play, and the next few years will be critical in establishing the pattern under which the future program will be administered.

The WPCF Government Affairs Seminar has been mentioned as one mechanism for interface between the technical and governmental communities. Another key date in providing interchange of ideas and increased understanding is the annual WPCF Conference. During that week the personal contacts and communications between the several thousand key members of the water pollution control field are perhaps of equal importance to the technical communications presented in the papers and at the exhibits. There is also a continuing contact between the WPCF leadership, including officers and staff, and the Environmental Protection Agency, including top management and professional staff. Increasingly this collaboration and cooperation is repeated at the state and regional level.

In addition to informal contacts the Federation has formal input to the drafting and application of federal rules and regulations through several mechanisms. One of the Federation's greatest strengths is its active committee structure which includes several specialized committees that provide advice to the appropriate divisions of the Environmental Protection Agency. The WPCF Personnel Advancement Committee frequently reviews and advises on manpower issues. The WPCF Technical Practice Committee is involved and provides assistance on technical questions and technology transfer. Perhaps most important, the WPCF Government Affairs Committee has been extremely active in reviewing all forms of water pollution control policymaking at the federal government level and in making recommendations and providing support to the WPCF leadership.

Technical Advisory Group

Beginning with the appointment of a review committee for the original federal guidelines, a permanent committee has been established by the EPA Office of Water Programs, called the "Technical Advisory Group." I have been privileged to represent the Federation on this body and serve as its Vice Chairman and it has been a very valuable interchange between the private sector and the federal agency. Without fanfare this mechanism has been used to offer preliminary review of changes and additions to the Federal Guidelines on Design, Operation and Maintenance and preliminary consideration of proposed regulations. This cooperation has involved significant effort on the part of all participants but there have been equally significant benefits, both in the final product and in increased understanding and credibility of each others' viewpoints.

The amount of detail work and meaningful interchange of information in the preparatory stages of the regulations and guidelines has been great. In my opinion the use of the expertise demonstrated in this program has been very wise. It has been a satisfying and challenging assignment and we look forward to the very best results as the work on the present amendments continue.

It has been a great privilege to be here today, particularly because of the opportunity to share a few thoughts with you leaders of water pollution control in Japan. We look forward to the continuing opportunity to share experiences with you. We hope this visit is proving interesting and valuable and that we can in the future contribute to the better understanding of each other's problems.

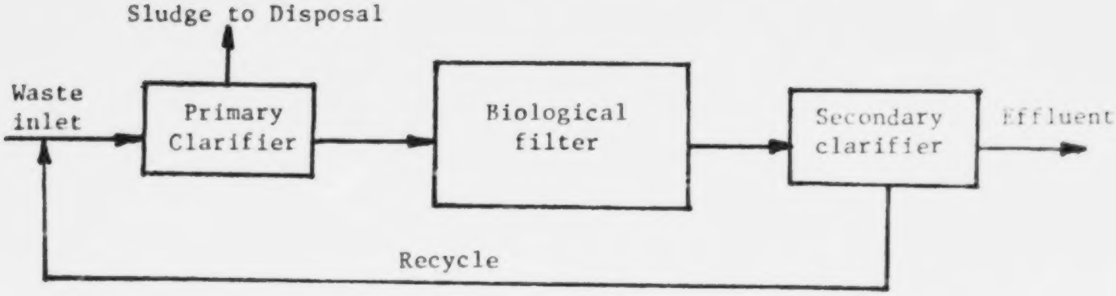
USE OF NEW TECHNOLOGY IN WASTEWATER TREATMENT PLANT DESIGN

by

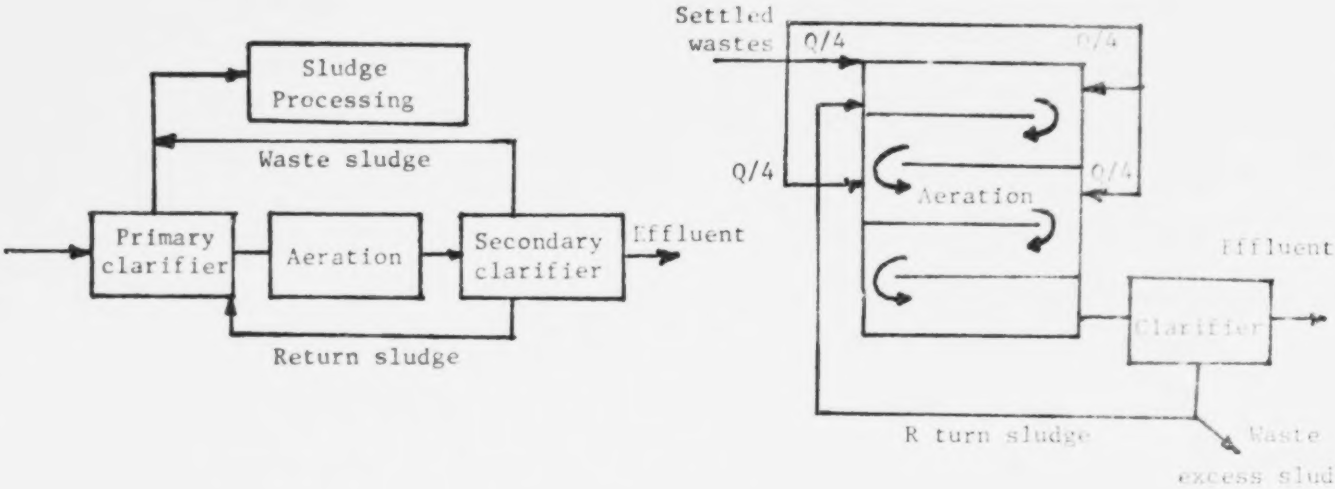
Robert S. Madancy

Until recently the accepted or "conventional" methods of municipal wastewater treatment in the United States were considered to be primary or secondary treatment basically consisting of sedimentation, biological treatment or a combination of the two. Biological processes usually consisted of trickling filters, activated sludge or the various modifications of the activated sludge process such as contact stabilization, extended aeration, and step aeration (See Figure 1). Oxidation ponds or lagoons also were and are widely used, particularly in the midwestern areas of the country. A summary of municipal wastewater treatment facilities in the United States in 1968, taken from the Federal Water Quality Administration's Municipal Inventory, is shown in Figure 2. It should be noted that only ten "Tertiary" or advanced wastewater treatment facilities were included in the inventory just four years ago. The ten tertiary facilities listed, however, were actually final polishing ponds or lagoons and were therefore not the type of treatment technology that we now consider as being "advanced".

CONVENTIONAL BIOLOGICAL TREATMENT SYSTEMS

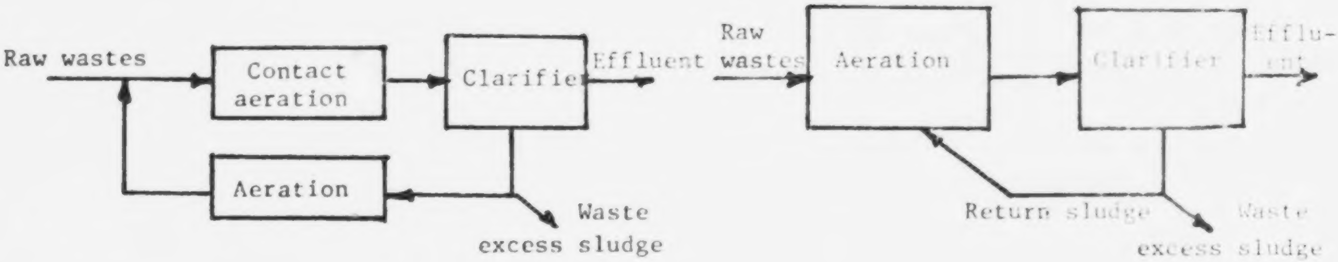


SECONDARY TREATMENT SYSTEM WITH TRICKLING FILTER



BASIC SYSTEM

STEP AERATION



CONTACT STABILIZATION

EXTENDED AERATION

ACTIVATED SLUDGE TREATMENT SYSTEMS

FIGURE 1

MUNICIPAL WASTEWATER TREATMENT SYSTEMS IN 1968

TREATMENT SYSTEM	NUMBER OF PLANTS	ESTIMATED POPULATION SERVED
Primary Treatment	2,384	36,947,000
Intermediate Treatment	75	5,858,000
Secondary Treatment		
Trickling Filters	3,786	28,419,000
Activated Sludge	2,110	41,264,000
Oxidation Ponds	3,457	6,123,000
Tertiary Treatment	10	325,000
TOTAL	11,822	118,936,000

NOTE: Does not include septic tank or non-sewered population.

FIGURE 2

In 1970, a concerted effort was initiated to insure that new wastewater treatment technology would be used, where appropriate, to avoid a large public investment in obsolete or less than optimum facilities, to adequately meet water quality standards, and to provide flexibility to meet future water quality requirements. This effort, known as the Technology Transfer Program of the Environmental Protection Agency, was charged with the task of effectively transferring operable technology developed by the research and demonstration programs of EPA, and by industry, to all potential users. A variety of mechanisms are used in the program to disseminate information on new treatment processes and methods. One extremely effective method has been the presentation of design seminars throughout the country, intended for design engineers employed by municipalities, states, and private consulting engineers. These engineers must be convinced that the new treatment processes are ready for full scale application, with a very small degree of risk. They must have knowledge of the basic design parameters and criteria involved. A total of 19 municipal design seminars have been held throughout the country as of the end of 1972. A listing of subjects included in the seminars may be found in Figure 3. A similar series of industrial seminars has recently been initiated for small industries. These industrial seminars cover all major aspects of environmental pollution control including air pollution, water pollution and solid waste disposal.

A parallel effort to the design seminars has been the development and dissemination of process design manuals which extract and consolidate the usable data and information from successful research and demonstration projects into a usable format for design engineers. These

NEW TECHNOLOGY SUBJECT AREAS INCLUDED IN TECHNOLOGY TRANSFER MUNICIPAL DESIGN SEMINARS

CARBON ADSORPTION

NITROGEN CONTROL

PHOSPHORUS REMOVAL

PHYSICAL-CHEMICAL TREATMENT

OXYGEN ACTIVATED SLUDGE

ADVANCED SUSPENDED SOLIDS REMOVAL

STORM AND COMBINED SEWER OVERFLOWS

UPGRADING EXISTING TREATMENT PLANTS

SLUDGE HANDLING AND DISPOSAL

COLD WEATHER TREATMENT

ADVANCED WASTEWATER FILTRATION

INFILTRATION CONTROL

FIGURE 3

TECHNOLOGY TRANSFER DESIGN MANUALS

PHOSPHORUS REMOVAL

UPGRADING EXISTING WASTEWATER TREATMENT PLANTS

SUSPENDED SOLIDS REMOVAL

CARBON ADSORPTION

* NITROGEN CONTROL

* SLUDGE HANDLING AND DISPOSAL

* SULFIDE CONTROL IN SEWERAGE SYSTEMS

** INFILTRATION CONTROL

- -

* Now under preparation

** To be started in 1973

FIGURE 4.

manuals include design criteria, estimated costs, performance data, equipment requirements, case histories and other critical information. A list of design manuals, both completed and now underway, is shown in Figure 4. Other mechanisms used in the Technology Transfer Program include audio-visual media such as technical closed-circuit videotapes, motion pictures, and various other publications describing new treatment processes and analyzing individual wastewater treatment projects. The Technology Transfer Program has had an enthusiastic and appreciative reception from the engineering community in the United States. More important, however, is the impact it is having on the adoption of new technology for design of new wastewater treatment facilities.

During the past two years, the adoption of new or advanced municipal wastewater treatment technology has accelerated at a dramatic rate. It is difficult to precisely determine the causes for the rapidly spreading acceptance of new technology. While we feel that a major amount of new treatment designs may be attributed directly or indirectly to the efforts of the Technology Transfer Program, it is undoubtedly true that other factors have also played a role. These include more stringent water quality standards and requirements, increased social awareness of environmental problems, institutional changes in State and municipal regulatory agencies and the efforts of professional engineering organizations.

WATER QUALITY MANAGEMENT PLANNING:
A CONSTRUCT FOR LOCAL-STATE-FEDERAL COOPERATION

I am especially pleased to be here because, historically, through transfer and cross-fertilization some of our best ideas have been achieved. Since the planners' job is to translate ideas into a practicable construct for implementing and achieving a goal, I look forward to benefitting from a differing outlook and approach to our common problems.

I. New Planning Goals and Requirements

During the drafting phase and since passage of the new amendments to the Federal Water Pollution Control Act, the EPA has been reappraising the water program and its planning aspects in light of the new, stringent, and imminent goals of the act. It seemed clear if we were ever to achieve the goals of Best Practicable Treatment by mid-1977 and Best Available Treatment by 1983 for discharges into our navigable waters, water quality management plans must lay out a step-by-step course. In line with Congress' concern that plans be designed to attain the most clean-up, most efficiently, and at the least cost, the requisite level of planning for the localities, States and Federal Government was significantly increased by the act. For example:

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*Mark Pisano, Director, Water Planning Division, Air & Water Programs Office, EPA, to the Delegation from Japan Environment Agency, 12/5/72, Washington, D.C.

--Section 201 requires waste treatment management plans and provides assistance in developing and implementing these plans and related practices to achieve the goals of the act.

-- Section 208 authorizes areawide waste treatment management plans aimed at the urban industrial and other areas with serious water quality control problems. Before these plans can be developed and administered, a local planning authority with fund raising powers must be designated. undoubtedly, this is one of the most far-reaching provisions in the act, and its implications are not limited to its impact on land-use planning...or zoning. It promises, if fully implemented, to substantially impact all our existing local institutions.

--Section 209 requires development of comprehensive regional or river basin plans, called Level B plans, under the Water Resources Planning Act.

-- Section 303(e) requires the States to establish a continuing planning process which must be approved by EPA prior to State assumption of responsibility for the National Pollutant Discharge Elimination System, the State-Federal Permit System.

II States' Continuing Planning Process

Pertinent elements of all the plans I have described, plus the existing water quality standards, are incorporated in the 303(e) - required continuing planning process to be implemented by the individual States.

Along with these plans, which are complex, intricate, and upon examination partially redundant, a State planning program conforming with the requirements of such a unified, comprehensive planning process must fulfill:

> --First, the Section 303(d) provision that States identify their waters where the effluent limitations are not stringent enough to implement the water quality standards, rank these waters by priority, and establish total maximum daily pollutant loads.
>
> -- Second, the Section 305(b) requirement that the States submit an annual water quality report, including non-point as well as point-source pollutants, to the EPA Administrator, with a recommendation of additional measures to meet the

standards over and above those already being taken, together with estimates of the social and economic costs and benefits, and the environmental impact and date for achieving standards and goals. In brief, the report must assess present water quality and project future water quality. No longer are we asked just what is the water quality, but when will it get better.

--Third, the Section 314 requirement that the States submit control procedures to restore their fresh water lakes. Also grants for municipal waste treatment facilities construction and the requisite water quality monitoring and reporting are intimately tied to the development of this continuing planning process in the States. We are in the process of writing regulations and guidelines to aid the States in establishing this process. We expect they will be published in the FEDERAL REGISTER before the end of this month.

III Establishing Priorities - Priority Basin Accomplishment Planning

As you can see, the requirements of the new water act are substantial. Concomitantly, the funding at the local, State, and Federal levels will be substantially increased.

Because of the Congress' concern that the new goals be achieved in a timely and cost effective manner, a provision was inserted in Section 106 requiring that priorities be established. The concept of priorities is integral to our present planning efforts, and for some time we have been formulating and testing procedures to establish such priorities.

Another spur to our efforts has been our concern that the water program was not an integrated operation. Grants was doing one thing, planning another, and enforcement yet another.

In order to encompass the directives of the upcoming legislation and to enable planning to guide the action decisions taken by the States and EPA, some months ago under the existing act we developed Priority Basin Accomplishment Planning.

Since establishing realistic priorities is the linchpin to our program, we have included this concept in our draft continuing planning process regulations and guidelines.

IV What is Accomplishment Planning?

The thrust of this program is to produce tangible water quality improvement in selected high priority basins at an accelerated rate. This activity focuses a portion of regional resources in cooperation with the appropriate State and local governments and the private sector to gain specific, quantified objectives in stated time frames. The map provided points out the current priority basins....55 around the country.

A. Selection of Basins

The criteria used for selecting the priority river basins are... those basins where, in cooperation with the States, we can demonstrate results....where the problems are controllable, and more specifically, areas were selected as Priority Basins if they meet certain criteria.

-- Accomplishment of water quality goals by 1977 must be feasible through available authorities and technology;
-- The area must have a sizeable population; and
-- Its waters must be heavily polluted.

Because of these requirements:

-- Most Priority Basins are only portions of drainage basins;
-- Many Priority Basins will include all or part of a metropolitan area.

-- Major pollution problems in the Priority Basins come from municipal and industrial sources, including Federal facilities, rather than from non-point sources.

B. Content of Priority Basins

As the name, Priority Basin suggests, concentration of adequate resources to obtain water quality goals in these areas is being given highest EPA priority. This does not mean that longer range efforts to find new answers to pollution, or on developing basic nation-wide, State-wide, or Region-wide capabilities for effective action are being neglected or even given low priority. It does not mean that major dischargers subject to the permit program or water quality standards will be allowed to violate the law just because they are outside Priority Basins. It means that a new, concentrated effort will be made to obtain tangible water quality improvements at the earliest possible date between now and 1977 where such water quality accomplishments are clearly feasible. We need to demonstrate a viable management concept in water, one that integrates all the pieces from the program and insures accomplishment by key dates.

What is in these plans? What is the methodology?

-- All significant dischargers are identified and listed in priority order. The total basin loadings from these dischargers, including provision for growth, are calculated.

-- For each significant discharger or cluster of dischargers, the water quality data from the nearest downstream monitoring station is obtained.

-- This water quality data is then compared with the water quality standards for the basin or river reach and standards violations are noted.

-- From discharge information and ambient standards violations, an analysis is made to rank the dischargers as determined by their pollution effect.

-- Lastly, based on this ranking, an integrated program of implementation encompassing State and Federal grants, enforcement, planning, operations and maintenance, monitoring, and other resources is developed to guarantee compliance by 1977.

You might ask, what will these plans do that isn't being done already? We anticipate the following changes will help focus our efforts:

-- Major industrial discharges in Priority Basins should get first priority in the Permit Program, whether EPA's or the States'.

-- Highest priorities for needed municipal treatment facilities should be given to the Priority Basins, and EPA will work to insure that grants will be made at the earliest possible date;

-- Operations and maintenance strategy will be keyed to Priority Basin Accomplishment Planning to use these limited resources more effectively.

-- Our efforts to get hard, objective monitoring data will be focused in the Priority Basins, e.g., new U.S. Geological Survey stations are to be allocated there.

-- And, needed water quality planning for the Priority Basins will take first priority in EPA's planning grants and assistance program.

C. Priority Basin Accomplishment Reporting

In order to track State, local and Federal progress, we are developing a reporting system that keys on the major milestones and ambient objectives of the Priority Basin Accomplishment Plans. This reporting system provides:

-- Comparison of progress achieved with priority basin milestones;

-- Improved assessment of whether programs are achieving the ambient objectives as effectively as possible;

-- Regular identification, analysis, and review of problems facing Regions via flagging the exceptions; and

-- Strengthened incentives to concentrate the needed resources.

This reporting system will enable us to quickly identify lags and slippage in our implementation program. This information will enable both the Federal and State governments to redirect programs to correct the problem. If the problem is not easily addressed and national water quality targets will not be met, we will have a basis for knowing the reason why.

V. Conclusion

Priority Basin Accomplishment Planning is a construct for integrating the many, diverse activities to achieve our water quality goals. It is a format with a firm timetable against which we can check our aspirations and our actual achievements. Its reporting requirements will assure our ability to make on-course corrections and refine our planning methods and directions.

We are still in the trial stage. We would like to share our basin planning experiences with you. Pooling our knowledge will strengthen water quality planning in the spirit of global environmental cooperation.

Thank you.

DESIGN GUIDELINES FOR MUNICIPAL WASTEWATER TREATMENT WORKS*

Charles L. Swanson**

INTRODUCTION

With the rapidly increasing expenditures of public funds for municipal wastewater treatment, every effort must be made to ensure that the best available technology is utilized, that designs are cost-effective, and that facilities can be adequately operated and maintained. In order to achieve these goals there must be close coordination and cooperation between the local communities, consulting engineers, States and the Environmental Protection Agency (EPA). For this reason the Federal review responsibility for the engineering and design aspects of specific municipal wastewater projects eligible for Federal financial assistance is in each of the ten EPA Regional Offices. The EPA headquarters staff is responsible for establishing national engineering and design policy and preparing Design Guidelines and Technical Bulletins.

FEDERAL DESIGN GUIDELINES AND TECHNICAL BULLETINS

In October 1970, the EPA published the Federal Guidelines for Design Operation and Maintenance of Wastewater Treatment Facilities. These Guidelines outline in general terms EPA interests and policies with regard to wastewater treatment works design, operation, and maintenance. Technical Bulletins are also being issued to amplify subject areas contained in the Guidelines. The Technical Bulletins cover selected subject areas in detail, define and analyze deficiences in design and provide guidance for incorporation of new technology. Three Technical Bulletins were issued in October 1971 entitled Storage and Handling Facilities for Chemicals Utilized in Wastewater Treatment, Use of Mercury in Wastewater Treatment Plant Equipment and Use of New and Advanced Wastewater Treatment Technology.

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* Prepared for Second U.S.-Japan Conference on Sewage Treatment Technology, December 4-6, 1972, Washington, D. C.

** Chief, Engineering and Design Branch, Municipal Waste Water Systems Division, Office of Water Programs Operations, Environmental Protection Agency, Washington, D. C. 20460

Relationship to Other Design Standards

There is a wealth of reference material for the design of water pollution control facilities. Included are the Ten State Standards, Manuals of Practice published by the Water Pollution Control Federation and American Society of Civil Engineers, and standards issued by individual States.

Although these documents are generally adequate, EPA is not necessarily in full agreement with all criteria and concepts. Certain design considerations are not adequately emphasized, and sufficient guidance is not given in those areas where there have been recent technological advances.

Other design references are the Process Design Manuals prepared by the EPA Technology Transfer Program which contain information on new treatment techniques.

PHILOSOPHY OF GUIDELINES

The Federal Guidelines represent a baseline or lower limit that must be met unless a waiver is obtained from the Regional Administrator. These Guidelines and Federal Regulations published by EPA are the only documents on design that have legal significance. Process Design Manuals and research and development publications are not guidelines and are issued only to provide information on new developments.

It is not the intent of EPA to develop detailed guidelines in the form of design manuals or to develop "uniform" or "standard" treatment plant designs. Wherever possible, the use of "numbers" for design is being avoided. We believe that Federal Government effort in these areas is undesirable and would tend to discourage innovation in plant design.

The Federal Guidelines are not intended to cover all aspects of engineering design. They outline specific EPA interests and policies that we believe are not adequately reflected in existing design references. Topics are included which we want to be sure the designer considers if Federal grant funds are involved. Essentially, these are good design practices that have been used by many progressive States and consulting engineers, but which would be optional in the absence of guidelines.

APPROACH TO DEVELOPMENT OF GUIDELINES

The basic work in development of many of the Technical Bulletins is being accomplished by extensive use of architect/engineer firms with experience in the design, construction and operation of wastewater treatment facilities. In a few cases contracts have been awarded to firms having expertise in related fields in order to benefit from their experiences. For each Technical Bulletin subject, a comprehensive background study is prepared which includes an analysis of the effects of the proposed Guideline on capital, operating and maintenance costs, and on plant operating efficiency and reliability.

The EPA in-house program consists of contract development and monitoring, revisions to guidelines, and develpment of some Technical Bulletins.

The Regulations, Guidelines, and Technical Bulletins are reviewed by Regional Offices and a Technical Advisory Group. The Technical Advisory Group is composed of representatives of the major organizations associated with wastewater treatment design, construction and financing. Interested trade associations are also consulted during development and review of guidelines.

CURRENT PROGRAM

Technical Bulletins are being prepared in-house on oxidation pond, trickling filter process, and contact stabilization process design. For trickling filters, design and upgrading techniques are being defined to achieve the levels of secondary treatment required by the Federal Water Pollution Control Act Amendments of 1972. The objective of the study on contact stablization is to define a range of design parameters for satisfactory operation of plants with a capacity less than one million gallons per day. Other in-house programs include revision of the October, 1970 Guidelines to reflect changes in Agency policy and incorporate requirements of the new legislation.

Five contracts were awarded in Fiscal year 1972 for support of the design guideline program. Roy F. Weston is developing the requirements specified in the new legislation on industrial waste pretreatment and cost recovery guidelines, and definition of the degree of pollutant removal achievable by the application of secondary treatment.

MPR Associates is conducting a study on the reliability of mechanical, electrical, and fluid systems. The Black and Veatch contract consists of supporting studies on failure history and cost-effectiveness of proposed reliability criteria, and development of sewer system infiltration/inflow requirements specified in the new legislation. The American Public Works Association is surveying approximately 100 installations where wastewaters are applied to land. These data on land disposal will provide input to future guidelines required by the legislation.

Camp, Dresser and McKee is preparing Technical Bulletins on sludge handling and disposal, safety in plant design and operation, handling and treatment of unit process sidestreams, and environmental aspects of plant design and construction.

These Technical Bulletins now being prepared under contract are scheduled for completion by mid-1973. Works scopes for individual studies are described below.

Joint Municipal - Industrial Treatment

As required by new legislation, guidelines and standards are being developed for pretreatment of industrial and commercial pollutants discharged to publicly owned treatment works. The purpose of this work is to define pollutants which would interfere with, pass through, or be otherwise incompatible with treatment processes. The guidelines and standards will specify pretreatment functional requirements for industrial categories and types of municipal treatment systems.

The "Federal Guidelines - Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems" which were issued in October, 1971 to implement the July 2, 1970 regulations (18 CFR 601.34), are being revised to incorporate requirements of the new legislation. The legislation requires recovery of the grant portion from industrial users, through a system of user charges, including both capital costs and operating and maintenance costs. Other requirements of the legislation being developed include establishment of classes and categories of users, criteria for determining adequacy of imposed charges, and model systems and user charge rates.

Definition of Secondary Treatment

The new legislation requires a minimum of "secondary treatment" for all municipal wastewaters. A literature search and survey of approximately 80 well-operated "secondary" facilities have been conducted to obtain design and performance data. These data are being utilized to define the best effluent quality that can be reliably attained through the application of processes which historically have been considered secondary treatment. This definition will supercede the July 1971 regulations which required 85 percent removal of BOD and substantial removal of suspended solids and pathogens.

Reliability of Mechanical, Electrical and Fluid Systems

The contract studies will result in a Technical Bulletin on the subject of reliability of mechanical, electrical and fluid systems. This Technical Bulletin will expand on the concepts contained in the present Federal Guidelines.

Phase I of the study, which is now complete, produced a set of preliminary reliability criteria. Included in this phase was an evaluation of the practices of the commerical shipbuilding, nuclear utilities, defense, aerospace, and chemical industries as well as a review of the design of operating experiences of a number of waste treatment facilities.

The purpose of Phase II of the study is to produce a final set of reliability criteria. The scope of work for this phase includes:

1) Development of requirements for documents to be submitted by a grant applicant to demonstrate project reliability and procedures for review of these documents by the EPA Regional Offices.

2) A detailed evaluation of two existing wastewater treatment plant utilizing the criteria developed in Phase I of the project with technical assistance from the engineer and plant operator.

3) A trial review by the contractor and EPA Regional Office of a a document submittal prepared by the design engineer on an actual grant project involving a plant expansion and upgrading.

4) A survey of a number of wastewater treatment plants to determine the actual failure history of various systems, the causes of these failures, corrective steps that were taken or could have been taken to prevent frequent recurrance and the resulting degradation of effluent quality.

5) The increased construction costs, if any, associated with the proposed reliability criteria will be estimated for several pending grant projects.

Reduction of Infiltration/Inflow

A study of the methods of identifying, analyzing and reducing infiltration/inflow into, and rehabilitation of, sanitary sewer systems is being conducted. The study products will be proposed Regulations and Guidelines to implement new legislation.

Techniques will be defined for conducting a preliminary analysis of an existing sewer system to determine the presence of infiltration/inflow conditions and for detailed surveys. The costs for various levels of rehabilitation of the sewer system to correct infiltration/inflow conditions will be related to the additional costs of collection and treatment. A model ordinance will be developed which will prohibit connection of foundation drains, downspouts, and other clean water sources which do not normally require treatment for all new construction.

Survey of Wastewater Treatment by Land Application Methods

On-site surveys of approximately 100 representative existing facilities in the U.S. that practice land application of wastewaters are being conducted to obtain data such as design features, operational procedures, effectiveness of treatment, costs, and problem areas. The on-site surveys will be supplemented by a literature survey and a questionnaire survey of other identified facilities. The purpose of this work will be to obtain information on land disposal techniques as required by new legislation. EPA guidelines on this subject will be developed at later date.

Sludge Handling and Disposal

This study will identify probem areas in design of sludge handling and disposal facilities and will define future EPA activity in this area.

The tasks to be accomplished include:

1) A thorough examination of the information currently available on the subject of sludge handling.

2) Determination of gaps in available knowledge which should be filled in to improve the design and evaluation of sludge handling systems.

3) Identification of informational requirements which should be addressed in research, development, and demonstration programs.

4) Assignment of recommended priorities to the research needs based on their relative value in the design of municipal wastewater treatment systems.

5) Summarize the basic general criteria presently available for evaluating proposed sludge handling techniques and the information which should be contained in a feasibility report.

Safety in Design and Operation

Minimum Federal standards will be developed for the design, operation, and maintenance of interceptor sewers and treatment plants.

The following tasks will be accomplished.

1) Identify potential safety hazards.
2) Review pertinent regulations, codes, standards, manuals, and other literature pertaining to these safety hazards.
3) Determine the safety hazards which can be eliminated or reduced by proper design. The contractor must consider practicality when making this determination.
4) Define design and operational safety requirements and establish minimum standards.

Handling and Treatment of Process Sidestreams

This study will define optimum methods for handling process sidestreams such as digester supernatant, incinerator/scrubber water, elutriate, and recycle streams from other processes. The work scope includes the following:

1) Review the literature to obtain available information on the occurrence and characteristics of sidestream wastes in municipal wastewater treatment plants.
2) Summarize the information regarding the effect of recycling sidestreams into the main process stream.
3) Determine sidestream disposal methods which could be considered as acceptable alternatives to recycling.
4) Develop information on cost-effectivess of separate treatment of process sidestream and relative effect on plant efficiency.

Environmental Aspects of Plant Design and Construction

The purpose of this study is to develop criteria which will insure that design and construction of municipal wastewater treatment facilities are compatible with the environmental goals of the EPA. The study will provide engineers, municipalities, and regulatory agencies with guidelines and criteria for including environmental considerations in designing and evaluating proposed watewater treatment facilities and constructing the facilities within limits which will protect the environment.

Topics to be included are plant location and buffer areas, odor control, architectural appearance, noise, and protection during construction.

FISCAL YEAR 1973 PROGRAM

Contracts with architect/engineer firms are now being negotiated for Fiscal Year 1973. The following subject areas are being considered.

1) Corrosion control in wastewater treatment plants.
2) Sewer system design for odor and cor[illegible] control.
3) Design of ocean outfalls.
4) Cost-effectiveness of process design
5) Design of the activated sludge process for flexibility

Tentative contract work scopes for Fiscal Year 1973 are outlined below:

Corrosion Control In Wastewater Treatment Plants

This study will consist of a review of the literature and information from manufacturers on the occurrence, characteristics, prevention, control and costs of corrosion in treatment plants. Design and maintenance criteria will be developed for corrosion prevention and control and will be validated by a survey of selected treatment facilities. Structures and mechanical equipment will be identified where increased use of corrosion resistant materials should be considered.

Sewer System Design for Odor and Corrosion Control

The EPA Office of Research and Monitoring has completed a comprehensive demonstration program on odor and corrosion control in sewer systems. Research and development grant projects were conducted at Los Angeles County, California, Port Arthur, Texas, and Jefferson Parish, Louisiana. A basic study of oxygen and sulfide balances in sewer systems was conducted at Los Angeles County. Data were developed on requirements for design so that septicity does not occur. In-sewer aeration methods that were demonstrated at Port Arthur and Jefferson Parish included air and pure oxygen injection into force mains, pressurized aeration tanks, an eductor or air-lif pump in a gravity sewer, aspirated air U-tubes, and diffused air U-tubes.

Cost-Effectiveness of Process Design

The purpose of this work will be to provide engineers, municipalities, and regulatory agencies with guidance for selection of unit processes which result in cost-effective treatment works, as required by new legislation. A cost-effective treatment works is defined as a combination of unit processes, selected to produce a specific level of treatment, which will result in the least cost to the public without consideration of source of funds.

The first phase of the work will define techniques for selecting the most cost-effective process combinations for the treatment of municipal wastewater to meet the initial requirements of the legislation. The second phase will summarize unit process costs and establish relationships between these costs and efficiency of pollutant removal.

Design of the Activated Sludge Process for Flexibility

This study will define a range of design criteria for optimum flexibility of the activated sludge process. The specific topics to be covered include:

1) Piping flexibility to allow the use of various modifications of the activated sludge process.

2) Use of chemical treatment methods within the aerator and final clarifier to improve suspended solids removal.

3) Independent operation of multiple aeration tanks and final clarifiers.

The contractor will conduct a cost-effective analysis to define flexibility that should be included in process design.

SUMMARY

In summary, the basic mission of the EPA Municipal Wastewater Treatment Works Construction Program is to provide financial assistance to local governments in the construction of new, improved, and expanded wastewater treatment facilities. As part of this mission, the program must also ensure the effective design, adequate construction, and efficient operation and maintenance of these facilities. This is accomplished through national uniformity in the application of legislation and design guidelines.

To reach this objective without discouraging innovation, the EPA has avoided setting rigid standards and has instead published Design Guidelines and Technical Bulletins which allow flexibility and the exercise of engineering judgment.

FUTURE U.S.-JAPAN COOPERATION

Exchange of technical and program information on design of wastewater treatment facilities should be expanded. Copies of Regulation, Design Guidelines, and Technical Bulletins will be forwarded to the Head of the Japanese Delegation as they are completed. These documents can be discussed in more detail at the next Conference.

Discussions should be held on the possibility of Japanese engineers visiting the U.S. during the next year to study the design guideline program. Visits by U.S. staff engineers to Japan to obtain information on Government programs should be considered.

Remarks by Walter G. Gilbert

OPERATION & MAINTENANCE GUIDELINES FOR MUNICIPAL WASTEWATER TREATMENT WORKS

Presented at

Second U.S.-Japan Conference
on Sewage Treatment Technology

It has long been recognized that proper operation and maintenance of municipal wastewater treatment facilities is essential if the quality of our receiving waters is to be protected on a continuous basis. Poor operation and maintenance has plagued such facilities for many years. Operational and maintenance problems are generally attributable to a number of primary factors, including: (1) poor operator training; (2) inadequate staffing of treatment facilities; (3) inadequate financial resources to maintain proper maintenance; (4) inadequate treatment facilities or inadequate flexibility in design; (5) hydraulic overloading of treatment facilities, and; (6) inadequate regulation to insure that operational efficiencies are maintained at a high level. Treatment plant designs are generally based on meeting certain standards or requirements, such as water quality standards or effluent criteria prescribed in operating permits. These design criteria are established at a level necessary to protect water uses. The treatment plant operation must consistently then meet these design criteria if our water quality objectives are to be achieved.

The problem of poor operation of municipal waste facilities is generally widespread and seriously affects the quality of effluent discharged to receiving waters from many plants throughout the country. EPA has recorded, in a computer file, operational data resulting from inspections of 1,300 grant-funded municipal waste treatment facilities.

Of these 1,300, approximately 45 percent experienced some operational problems. It has been estimated that operational efficiencies of a majority of municipal waste treatment facilities could be increased anywhere from 30 to 60 percent. Therefore, the reduction of pollutants discharged to our receiving waters could be significant, simply through improved operation of existing treatment facilities.

EPA's operation and maintenance program has, in the past, been based upon the Federal grant program for financial assistance to municipalities to construct waste treatment facilities. Section 8 of our previous Federal Water Pollution Control Act required assurance from an applicant for a grant that any facilities constructed with Federal grant funds would receive proper operation and maintenance. Beginning in 1962, EPA's predecessor agency began an inspection program to determine if treatment facilities funded by the grant program were, indeed, achieving design operation efficiencies. Due to limited resources available, this initial inspection effort was carried on at a low level. In the late 1960's, increased efforts were placed on assuring that grant-funded projects would receive proper operation and maintenance. The number of Federal inspections on grant-funded projects was increased, and in the Fall of 1969, "Federal Guidelines for the Design, Operation and Maintenance of Waste Water Treatment Facilities" were issued to give guidance to grant applicants for the establishment of adequate programs to operate and maintain municipal waste treatment works.

In July of 1970, Federal regulations were published which established specific requirements that a grant applicant must meet with respect to the establishment of a proper O&M program. These regulations specifically require the preparation of an operation and maintenance manual for the facility which is to be constructed, including an emergency readiness plan, provisions for properly trained personnel to operate and maintain the treatment works, reports on operational efficiency of the plant, and a state inspection program for grant-funded plants. These inspections are to be conducted on an annual basis for the first three years and periodically thereafter as required. The previously mentioned "Federal Guidelines" provide the detailed guidance necessary to comply with these Federal regulations.

The recently passed Federal Water Pollution Control Act Amendments of 1972 preserve and strengthen somewhat the requirements for proper operation and maintenance of municipal wastewater facilities constructed with Federal grant assistance. Section 204 of the new Act now requires that an applicant for Federal grant assistance provide a plan which is approved by the state water pollution control agency for the operation and maintenance of those facilities. This new procedure, and other changes needed to strengthen the operational and maintenance requirements for municipal treatment facilities, will be included in the new Federal regulations now being prepared by EPA. Congress has also expressed its increasing concern for proper operation and maintenance of municipal facilities by requiring, in Section 210 of the new Act, that EPA conduct an annual survey of the operational efficiency of such plants, and make a report to Congress of the results of that survey. Other provisions of the new Act, such as the permit program, which will establish specific effluent criteria and operational efficiency levels, provide additional tools to increase the operational efficiency of all municipal wastewater treatment facilities.

EPA's present O&M program emphasizes a limited number of areas in its effort to stimulate better operation and maintenance. These activities are carried out through EPA's ten regional offices and include the following:

(1) Compliance inspections of grant-funded treatment projects. These inspections are carried out after the plant has been operating for one year. Since 1968, approximately 2,500 compliance inspections have been conducted.

(2) Reviews of operation and maintenance manuals required as part of the grant-funded project. These reviews are designed to assure that the O&M manual will serve as a useful tool for improving the operation of the treatment works.

(3) Reviewing the proposed plant staffing plans for grant-funded projects to insure that adequate staff will be provided when the plant goes into operation.

(4) Working with the state agencies to improve their operation and maintenance programs, particularly in the areas of treatment plant inspections. EPA has recently initiated a training course to instruct state inspectors in the proper way in which to conduct an inspection of a municipal treatment facility.

Along with the ongoing program conducted through EPA's regional offices, the Headquarters O&M Branch is working to improve and expand the O&M program. The development of the O&M program is proceeding through emphasis in a number of areas considered essential to the conduct of any properly established and conducted operation and maintenance program. These areas include the following:

(1) The establishment of adequate administrative procedures. For EPA's national O&M program, the emphasis is on program development and implementation and the use of new regulations and legislative requirements to strengthen the O&M program.

(2) The development of new techniques which can be used in the treatment facility to improve overall operational efficiency. These include the development of new maintenance techniques and maintenance management procedures and the improvement of management practices. Also included are improved operation and maintenance manuals, staffing guidelines, research and development into new techniques, the use of public relations to improve the image of the treatment plant operator and the treatment facilities themselves, and the development of laboratory guidelines to aid in the design of laboratory facilities, the determination of adequate laboratory tests and testing frequencies, and the proper staffing of laboratories.

(3) The use and development of inspection and regulation procedures to assure high levels of operational efficiency. Efforts in this area would be designed to improve Federal and state inspection

programs and inspection techniques and to establish a basis for development and implementation of operator and laboratory certification programs.

(4) Development of a technical assistance capability. The emphasis in this area would be to provide technical assistance to those treatment facilities which, for some reason, do not have adequate capability to solve unique or complex problems which are affecting operational efficiencies. This effort could also be used to help in the start-up of new treatment plants. Technical assistance efforts would also provide the benefit of demonstrating the benefits of better operation and maintenance of treatment works, and would provide a training effect in the field.

(5) Better and more effective utilization of present training programs. Emphasis would be placed on better utilization of the present operator training programs now conducted by the Manpower Development Staff of EPA's Office of Water Programs Operations.

(6) Use of data collection and evaluation to demonstrate the quantitative benefits of better operation and maintenance. One of the present problems in promoting O&M programs has been the difficulty in demonstrating the improvement of receiving water quality resulting from better operation and maintenance. The establishment of a better data base and the routine collection of operational data will begin to establish the comparative capability necessary to demonstrate program results. The establishment of the new

permit program as required by the recently passed legislation will greatly assist in the collection and use of operational data.

EPA now has underway a number of major activities which will assist in the development of some of the program elements identified above. There are a number of contract activities which will provide some of the technical tools needed to improve the capabilities to provide better operation of treatment works and which will serve as sources of information for the improvement and expansion of the "Federal Guidelines" mentioned previously. These new guidelines will be published sometime next year, and will serve as a base document to guide applicants for Federal grant assistance in the development of proper operation and maintenance programs. Some of the contract activities which are now underway will deal with the following topics: plant staffing, laboratory guidelines, a plant rating system, development of a model State/Federal O&M program, advanced maintenance management program, emergency programs dealing with operational breakdowns at municipal wastewater treatment facilities, techniques for start-up of new municipal wastewater treatment facilities, guidelines for preparation of an operation and maintenance manual, and middle-management concepts for municipal wastewater operations.

With this variety of activities, and the development of a strengthened operation and maintenance program in EPA, and with the expanded legal basis as provided by the new Federal Water Pollution Control Act Amendments of 1972, it is believed that a significant improvement in the operational efficiency of a majority of municipal wastewater treatment facilities throughout the country can be achieved. This is a large task and will take years to accomplish, but the result will be an improvement in the water quality of our rivers, lakes, and streams.

GUIDELINES FOR JOINT TREATMENT OF MUNICIPAL AND INDUSTRIAL WASTEWATERS [1]

By

Charles H. Sutfin [2]

INTRODUCTION

It has been estimated [3] that in 1968, 241,000 water-using manufacturing establishments in the United States discharged some 14 trillion gallons of wastewater. Of this amount, only 30 percent was treated before discharge. Of that treated approximately one-fourth or one trillion gallons was treated in publicly owned treatment facilities.

Treatment in publicly owned facilities is the primary method of preventing pollution from the food processing, textiles, rubber, leather, and various metal fabricating industries.

1/ Prepared for the Second U.S./Japan Conference on Sewage Treatment Technology, December 4-6, 1972, Washington, D. C.

2/ Deputy Chief, Engineering and Design Branch, Municipal Waste Water Systems Division, Office of Water Programs Operations, Environmental Protection Agency, Washington, D. C. 20460

3/ The Economics of Clean Water, Volume I. Environmental Protection Agency, 1972

It is expected that the Federal Water Pollution Control Act Amendments of 1972 (hereinafter referred to as the Act) will drastically change these statistics.

The Act requires that all industries obtain a permit for discharge of wastewaters to navigable waters of the United States. The Act further requires that, as a minimum, all industries treat their wastewaters by the application of the best practicable control technology by July 1, 1977. By 1983, the application of best available treatment technology must be achieved by all industries, as a minimum.

Municipalities must also obtain a permit to discharge to navigable waters. All publicly owned treatment works must achieve a minimum of secondary treatment by 1977 and best practicable treatment technology by 1983.

The ultimate goal of the Act is to eliminate the discharge of pollutants to navigable waters by 1985.

Two provisions in the Act relate to treatment of industrial wastewaters in publicly owned treatment facilities. Approximately four years after enactment, July, 1976, all industrial discharges into publicly owned treatment works must be pretreated to prevent the introduction of pollutants which may interefere with, pass through inadequately treated or otherwise be incompatible with such works.

In addition, the Act states that Federal financial assistance can be provided for construction of publicly owned treatment works treating industrial wastewaters, only if the municipality has adopted a system of charges to assure that each recipient of wastewater treatment services will pay its proportionate share of the costs of operation and maintenance; has made provision for payment by industrial users of that portion of construction costs allocable to the treatment of industrial wastes to the extent of the Federal share; and has the legal, institutional, and financial capability to insure adequate construction, operation and maintenance.

The Environmental Protection Agency (EPA) is required to publish guidelines relating to pretreatment of industrial wastes and user charges for industries receiving waste treatment services in publicly owned treatment facilities. The following discussion relates to the development of these guidelines and their expected national impact.

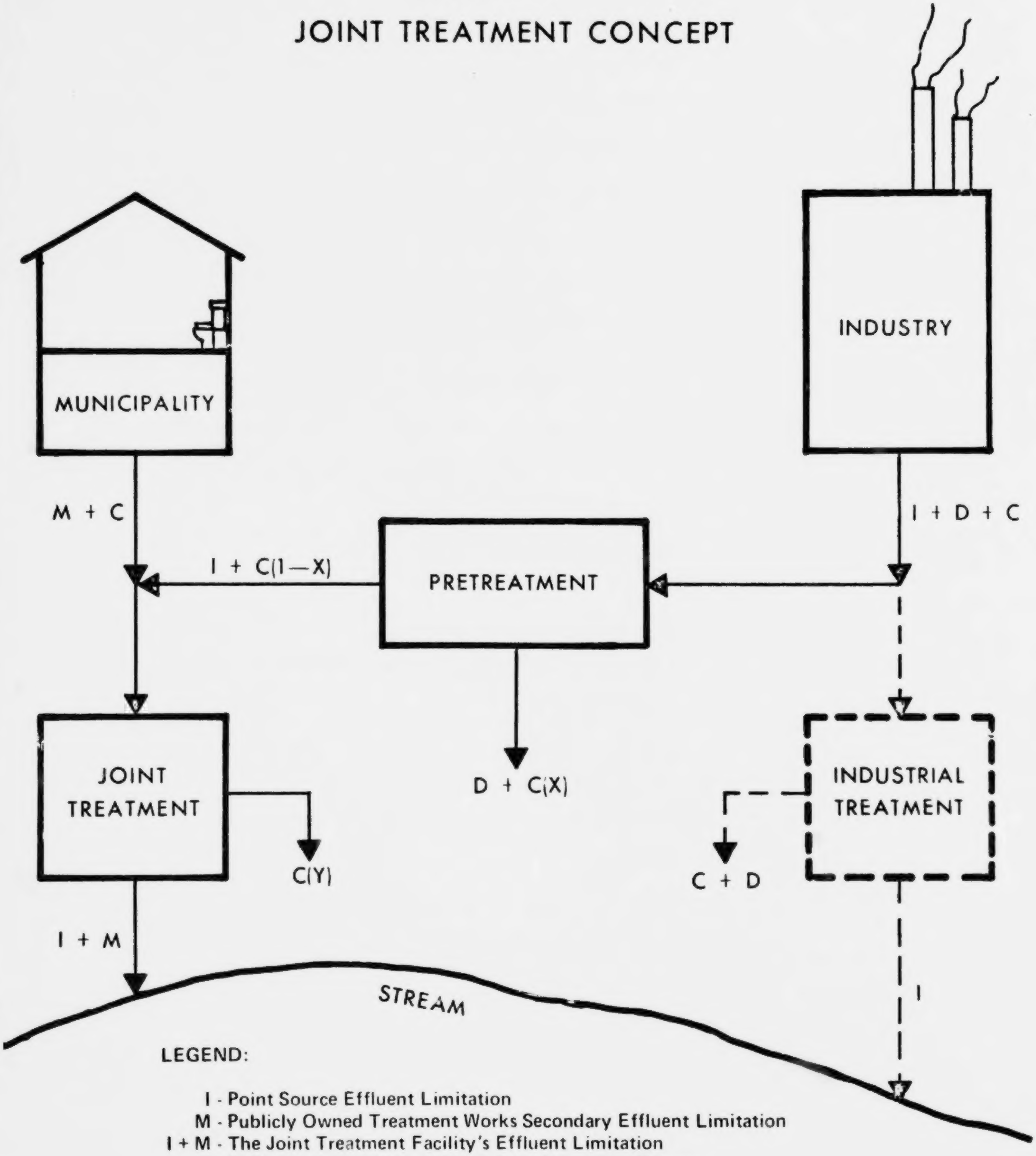
PRETREATMENT GUIDELINES

General Concepts

The concepts used as the basis for developing the pretreatment guidelines are best described by reference to Drawing No. 1 entitled "Joint Treatment Concept".

DRAWING 1

JOINT TREATMENT CONCEPT



LEGEND:

I - Point Source Effluent Limitation
M - Publicly Owned Treatment Works Secondary Effluent Limitation
I + M - The Joint Treatment Facility's Effluent Limitation
C - Pollutant Compatible with the Joint Treatment Process
D - Pollutant Incompatible with the Joint Treatment Process
X & Y - Fractional Numbers

The Drawing represents a "one-industry" joint treatment system. The industry has two choices for treatment and disposal of its wastes --- either through a joint treatment facility or through a strictly industrial treatment facility (dashed lines). The various components of the municipal and industrial wastewaters are represented by the letters M, I, C and D as defined in the Legend.

The component (I) represents the industrial point source effluent limitation based on the effluent quality attainable by the application of the best practicable or best available treatment technology for an industrial category.

The component (M) represents the municipal effluent limitation based on the effluent quality attainable by the application of secondary treatment or best practicable treatment technology to wastewaters of domestic origin.

From the municipal (M) and industrial (I) components, a joint effluent limitation (M+I) would be derived. This relationship demonstrates an important concept used in developing the pretreatment guidelines. The quantity of pollutants discharged from a publicly owned treatment facility, attributable to an industrial source, should not be greater than that permitted for direct discharge to a navigable waterway. In other words, the magnitude of (I) should remain constant for treatment of the industrial wastewater in either a joint treatment facility or a strictly industrial treatment facility.

Incompatible pollutants (D) are those which would either cause harm to, adversely affect the performance of or be inadequately treated in publicly owned treatment works. The pretreatment guidelines will specify the minimum pretreatment unit operations necessary to effect removal of those incompatible pollutants which would cause harm to or adversely affect the performance of categories of joint treatment systems. Additional pretreatment will be required to remove those incompatible pollutants which would be inadequately treated in the joint treatment facility.

In joint treatment systems involving many industry discharges, the cumulative effect of these discharges could adversely affect the joint treatment process even if the pretreatment unit operations specified were provided. Therefore, the guidelines will also specify influent limitations for various pollutants (primarily toxic pollutants). In a case where the cumulative concentration of a pollutant was higher than the influent limitation, the pretreatment requirements would be more stringent.

Pretreatment of pollutants compatible with the joint treatment process (C) will not be required unless it can be demonstrated that it would be more cost-effective than joint treatment of the combined wastewaters.

There will be no restrictions on ownership of the pretreatment facility or on responsibility for operation and maintenance. If the ownership, operation and maintenance of the pretreatment facility were retained by the industry, it would be responsible for the effluent from that facility [I + C (1 - X)]. If the municipality owned, operated and maintained the pretreatment facility, the industry would be responsible for its raw wastewater [I + D + C]. Pretreatment facilities would not be eligible for a grant regardless of ownership or location.

Permits will not be required for industries discharging into municipal systems. However, municipal permits must reflect the pretreatment required of each industry in terms of wastewater quantity and quality discharged to the municipal system. The pretreatment requirements contained in the municipal permit will be directly enforceable on the industry by the EPA or State Agency in cases where failure by an industry to provide pretreatment would cause a municipality to violate the joint effluent limitation (M+I) in the permit.

Guideline Specifics

Draft pretreatment guidelines based on the above concepts have been prepared and are now being reviewed and finalized.

A section of the guidelines specific to each of the industrial categories shown in Table No. 1 below is included.

Table 1

Industrial Categories Included In Pretreatment Guidelines

- Aluminum
- Beet and Cane Sugar
- Beverages
- Blast Furnaces, etc.
- Dairy
- Electrical and Steam Generation
- Feed Lots
- Fruits and Vegetables
- Grain Milling
- Industrial Gases
- Inorganic Chemicals
- Inorganic Fertilizers
- Leather Tanning
- Meat
- Metal Finishing-Auto Parts
- Paper and Allied Products
- Pesticides
- Petroleum Refinery
- Pharmaceuticals
- Plastic and Synthetics
- Seafoods
- Stone, Clay, Glass, and Concrete Products
- Synthetic Organic Chemicals
- Textiles

The selection of these categories was based on the availability of information on pretreatment and the compatibility of the industrial wastewaters, following pretreatment, with conventional municipal wastewater treatment processes.

For each industry category, the following information is included to illustrate the limitations of the recommended pretreatment unit operations:

1. Products covered and extent of coverage.
2. Description of the manufacturing process.
3. Type of operation - continuous batch, seasonal, etc.
4. Wastewater sources.
5. Type of wastewater collection system.

The wastewaters from each industrial category are divided into subcategories with similar characteristics and therefore similar pretreatment requirements. The characteristics of wastewaters from each industry subcategory are then classified relative to normal domestic sewage by means of the system shown in Table No. 2.

Table 2

System Used to Classify
Ranges of Industrial Wastewater Characteristics

Characteristic	Classification Low	 Average	 High
BOD5, mg/l	<200	200-300	>300
COD, mg/l	<300	300-400	>400
SS, mg/l	<200	200-300	>300
TDS, mg/l	<500	500-600	>600
Temperature, $^{\circ}$C	<15	15-25	>25
pH	<6	6-8	>8

Other characteristics not shown in Table No. 2 are indicated as present or absent. In the case of nutrients, such as nitrogen and phosphorus, the terms adequate or deficient are used to indicate whether quantities are sufficient to support biological growth in the Biological treatment processes.

An example of the wastewater characterization for an industry category is shown in Table 3. The wastewater characteristics shown in capital letters are those which are of concern in pretreatment and joint treatment of the wastewaters from that industry subcategory.

Finally, in Table 4, the pretreatment requirements for each industry subcategory are presented. The requirements are related to types of joint treatment processes:

1. Suspended biological growth (activated sludge, etc.)
2. Fixed biological growth (trickling filters, etc.)
3. Independent physical/chemical

As explained previously, provision of these pretreatment unit operations is intended to effectively prevent the discharge of pollutants which would cause harm to or adversely affect the performance of the joint treatment facilities. For large multiple-industry joint treatment systems, additional pretreatment would be required if the cumulative concentration of a pollutant exceeded the value shown in Table 5.

Table 3

Wastewater Characterization
Industry Category X

Characteristic	Subcategory A	Subcategory B
Flow	INTERMITTENT	INTERMITTENT
BOD	AVERAGE-HIGH	HIGH
TSS	HIGH	HIGH
TDS	AVERAGE-HIGH	HIGH
COD	AVERAGE-HIGH	HIGH
Grit	Absent	Absent
Cyanide	PRESENT	ABSENT
Chlorine Demand	AVERAGE-HIGH	HIGH
pH	ACID-BASIC	ACID-BASIC
Color	Average-High	Average-High
Turbidity	Average	High
Explosives	Present	Present
Dissolved Gases	Absent	Absent
Detergents	PRESENT	PRESENT
Foaming	PRESENT	PRESENT
Heavy Metals	PRESENT	ABSENT
Aquatic Toxicity	Positive	Negative
Colloidal Solids	High	High
Volatile Organics	HIGH	HIGH
Pesticides	Absent	Absent
Phosphorus	DEFICIENT	DEFICIENT-HIGH
Nitrogen	DEFICIENT	DEFICIENT-HIGH
Temperature	Average-High	Average-High
Phenol	Absent	Absent
Sulfides	Absent	Absent
Oil & Grease	Absent-Present	Absent-Present
Coliform (Total)	Absent	Absent-Present

TABLE 4

PRETREATMENT REQUIREMENTS INDUSTRY CATEGORY X

	Joint Treatment Process		
Subcategory	Suspended Biological Growth	Fixed Biological Growth	Independent Physical Chemical
A	Chemical Treatment (Heavy Metals) + Solvent Separation + Equalization + Neutralization + Cyanide Oxidation	Chemical Treatment (Heavy Metals) + Solvent Separation + Equalization + Neutralization + Cyanide Oxidation	Chemical Treatment (Heavy Metals) + Solvent Separation + Equalization + Neutralization + Cyanide Oxidation
B	Solvent Separation + Equalization + Neutralization	Solvent Separation + Equalization + Neutralization	Solvent Separation + Equalization + Neutralization

Table 5

Concentrations of Pollutants which Inhibit Biological Treatment Processes

	Concentration, mg/L		
Pollutant	Activated Sludge & Trickling Filter	Anaerobic Digestion	Nitrification
Copper	1.0	1.0-2.5	0.5
Zinc	5.0-10.0	5.0	0.5
Lead	0.1	*	0.5
Cadmium	*	0.02	*
Boron	1.0	*	*
Arsenic	*	4.0	*
Chromium^{6+}	1.0	1.0-5.0	2-5
Chromium^{3+}	1.0-10	1.0-5.0	*
Total Chromium	3.0	1.0-5.0	*
Nickel	1.0-3.0	2.0	0.5
Cyanide (HCN)	1.0	1.0-2.0	2.0
Sulfides ($S^=$)	*	150-200[2]	*
Sulfate ($SO_4^=$)	*	500	*
Ammonia	*	1,500-3,000	*
Salts (NaCl)	10,000 mg/L	*	*
Chloroform	10.0	*	*
Free Oil[3]	50.0	*	*
Sodium (Na^+)		0.3 moles/L	
Potassium (K^+)		0.1 moles/L	
Calcium (Ca^{++})		0.5 moles/L	
Magnesium (Mg^{++})		0.1 moles/L	

*Available data are insufficient to establish a reasonable standard.

[1] Concentrations refer to those present in raw wastewater unless otherwise indicated.

[2] Sulfide concentrations apply to the digester influent only. Lower values may be required for protection of previous treatment units.

[3] Oil concentration measured according to the API Method 733-58 for the determination of volatile and non-volatile oily material.

Additional pretreatment may also be required for those pollutants which are inadequately treated in the joint treatment facilities.

USER CHARGE GUIDELINES

Existing Program

Federal Guidelines for Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems were published in October, 1971. The objective of these Guidelines was to ensure that local capital, operation and maintenance and debt service charges would be recovered from industry proportionate to the costs of treating industrial wastes.

Program Under Act Amendments

Under the 1972 Act Amendments the objectives of the existing industrial waste cost recovery program are changed substantially. By March, 1973 industrial users of publicly owned systems are required to pay that portion of construction costs allocable to the treatment of industrial wastes to the extent of the Federal share not the local share as before. The user charge system adopted by a municipality must assure that all recipients of wastewater treatment services pay their proportionate share of the cost of operation and maintenance.

In addition, the Act establishes an amount of revenues recovered from industry, attributable to the Federal share, which may be retained by the grantee. This amount is equal to the sum of the non-Federal project costs paid by the grantee plus the estimated cost of future expansion and reconstruction of the project, except that such amount cannot exceed 50 pe cent of the revenues from industry attributable to the Federal share.

Guidelines are required to establish classes of users, including categories of industrial users; criteria against which to determine the adequacy of user charges; and model systems and rates of user charges. These guidelines must be published by April 18, 1973.

EPA regulations governing the determination of the amount necessary for future reconstruction and expansion are required. No deadline is given for the promulgation of these regulations.

A project to develop the guidelines and regulations required by the Act is just getting underway. There are a considerable number of complicated policy issues which must be decided before the final guidelines and regulations can be written. Many of these issues involve alternative interpretations of the section of the Act relating to the return to the Treasury of Federal funds attributable to the treatment of industrial wastewater. It is expected that a draft of the guidelines and regulations will be complete early in January 1973.

Summary and Conclusions

The Federal Water Pollution Control Act Amendments of 1972 establishes an ambitious program for control of industrial waste discharges into publicly owned treatment facilities.

By July, 1976, industrial discharges into publicly owned treatment works, must be pretreated, if necessary, to prevent the introduction of pollutants, which may interfere with, pass through inadequately treated, or otherwise be incompatible with such works.

By March 1, 1973, all industrial users of publicly owned treatment works are required to pay that portion of construction costs allocable to the treatment of industrial wastes, to the extent of the Federal share.

Approximately 70 percent of the wastewater discharged from U. S. industry in 1968 was untreated. About one-fourth of the remainder was treated in publicly owned treatment works.

The pretreatment and user charge requirements will represent a significant impact on industrial users of municipal systems. However, restriction on direct discharges by industry will be theoretically equal. The quantity of pollutants discharged from a publicly owned treatment facility, attributable to an industrial source should not be greater than that permitted for direct discharge. It is expected that because of economies of scale, of the fact that many municipalities have existing plants capable of handling pretreated industrial wastes, and for other similar reasons, the percentage of the total industrial waste local discharged into joint treatment systems will increase.

DEVELOPMENT OF EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS

BY

ALLEN CYWIN
DIRECTOR, EFFLUENT GUIDELINES DIVISION

ENVIRONMENTAL PROTECTION AGENCY

The Federal Water Pollution Control Act Amendments of 1972 (the "Act") requires the United States Environmental Protection Agency to establish effluent limitations which must be achieved by point sources discharging into the navigable waters of the United States. Section 301 requires (1) the achievement by July 1, 1977, of effluent limitations which require the application of the "best practicable control technology currently available" and (2) the achievement by July 1, 1983, of effluent limitations which require the application of the "best available technology economically achievable."

Within one year of enactment the Administrator is required by Section 304(b) to promulgate regulations providing guidelines for the effluent limitations required to be achieved under Section 301 of the Act. These regulations are to identify in terms of amount of constituents (including thermal) and the chemical, physical, and biological characteristics of pollutants, the degree of effluent reduction obtainable through the application of the "best practicable control technology currently available" and the "best available technology economically achievable." The regulations must also specify factors to be taken into account in identifying the two statutory technology levels and in determining the control measures and practices which are to be applicable to point sources within given industrial categories or classes to which the effluent limitations apply.

In addition to his responsibilities under Section 301 and 304 of the Act, the Administrator is required by Section 306 to promulgate standards of performance for new sources. These standards are to reflect the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the "best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants."

The Office of Air and Water Programs of the Environmental Protection Agency has been given the responsibility by the Administrator for the development of effluent limitation guidelines and new source standards as required by the Act. The Act requires (1) the effluent limitations guidelines for existing sources to be published by October 18, 1973, and (2) new source performance standards to be published by January 15, 1974, for the following 27 industrial categories:

1. Pulp and paper mills
2. Paperboard, builders paper and board mills
3. Meat product and rendering processing
4. Dairy product processing
5. Grain mills
6. Canned and preserved fruits and vegetable processing
7. Canned and perserved seafood processing
8. Sugar processing
9. Textile mills
10. Cement manufacturing
11. Feedlots
12. Electroplating
13. Organic chemicals manufacturing
14. Inorganic chemicals manufacturing
15. Plastic and synthetic materials manufactuirng
16. Soap and detergent manufacturing
17. Fertilizer manufacturing
18. Petroleum refining
19. Iron and steel manufactuirng
20. Nonferrous metals manufacturing
21. Phosphate manufacturing
22. Steam electric powerplants
23. Ferroalloy manufacturing
24. Leather tanning and finishing
25. Glass and asbestos manufacturing
26. Rubber processing
27. Timber products processing

Moreover, each of these industrial categories most likely will require further subcategorization in order to provide standards that are meaningful.

In order to develop the required guidelines and standards, it is first necessary to (a) categorize each industry; (b) characterize the waste resulting from discharges within each industrial category and subcategory; and (c) identify the range of control and treatment technology within each industrial category and subcategory. Such technology must then be evaluated in order to determine what constitutes the "best practicable control technology currently available," what is the "best available technology economically achievable," and for new sources what is the "best available demonstrated control technology."

In identifying the technologies to be applied under Section 301, Section 304(b) of the Act requires (1) with respect to assessing what constitutes the "best practicable control technology currently available" that the (a) non-water quality environmental impact (including energy requirements) and (b) the total cost of application of such technology in relation to the effluent reduction benefit to be achieved from such application be considered and (2) with respect to assessing what constitutes "best available technology economically achievable" that (a) the cost of achieving such effluent reduction and (b) the non-water quality environmental impact (including energy requirements) be considered.

Because of the complexity and scope of the task required by the Act, as well as the stringent time restraints, the above information will be obtained and initial analysis performed with the assistance of contractors.

The following is a summary of the study which will be made with the assistance of contractors of each of the 27 source categories to implement Sections 304(b), 306(b) and 316 of the Act.

I. INDUSTRY CATEGORIZATION

In developing effluent limitations guidelines and standards of performance for new sources for a given industry, a judgment must be made by EPA as to whether separate effluent limitations and standards of performance are appropriate for different segments within a given industry.

EPA has preliminarily divided each industry into broad categories which will be treated separately for the purpose of developing effluent limitations and standards.

In most cases, these broad categories must be further subdivided. Such subcategorization may be based upon (a) raw material used, (b) product produced, (c) manufacturing process employed, and (d) other factors.

II. WASTE CHARACTERIZATION

The raw waste characteristics for each category and/or subcategory of each industry must be identified. Raw waste characterization involves an analysis of the (1) source, flow and volume of water used in the process employed and the sources of waste and wastewaters in the plant and process; and (2) the constituents (including thermal) and the physical, chemical and biological characteristics of all wastewaters, including the toxic constituents and other constituents which result in taste, odor, and color in the water or aquatic organisms. Once this information is obtained, the constituents of the wastewaters which should be the subject of effluent limitations and standards of performance must be identified.

III. CONTROL AND TREATMENT TECHNOLOGY

The full range of control and treatment technology existing within each industrial category and/or subcategory must be identified.

This includes identification of and a description of each distinct control and treatment technology, including both in-plant end-of-process technologies, which are existent or capable of being designed for each category in terms of the amount of constituents, (including thermal) and the chemical, physical, and biological characteristics of pollutants, the effluent level resulting from the application of each of the treatment and control technologies.

The problems, limitations and reliability of each treatment and control technology and the required implementation time must be also identified. In addition, the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation must be identified.

IV. EVALUATION OF THE CONTROL AND TREATMENT TECHNOLOGIES TO DETERMINE WHAT CONSTITUTES "BEST PRACTICABLE CONTROL TECHNOLOGY AVAILABLE," "BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE" AND "BEST DEMONSTRATED CONTROL TECHNOLOGY"

Once the data base, as outlined above, is obtained, it must then be evaluated to determine what levels of technology satisfy the definition of "best practicable control technology currently available," "best available technology economically achievable" and "best available demonstrated control technology."

The Act itself does not define these statutory technology levels although these or similar terms are discussed to some extent in the legislative history proceeding enactment (Senate Report No. 92-414, pp. 44, 50-52; House Report No. 92-911, pp. 101-103, 107-108; Senate Report No. 92-1236, pp. 120-121, 128). EPA will, of course, exercise its independent judgment in determining what levels of technologies satisfy these statutory terms for each industry for which effluent limitations guidelines and standards of performance for new sources are to be promulgated. However, we have developed an outline of these statutory terms which are to be used by the contractors in setting forth suggested effluent limitation and standards of performance. Factors receiving consideration in this outline may technically go beyond those which EPA is legally required to consider under the Act. EPA may take into account factors other than those listed herein or elsewhere when finally promulgating effluent limitations guidelines and standards of performance for new sources.

"Best practicable control technology currently available" must be achieved by all plants and each industry not later than July 1, 1977. In general, "best practicable control technology is based upon the average of the best existing performance by plants of various sizes, ages, and unit processes within each industrial category or subcategory.

This average is not based upon a broad range of plants within an industrial category or subcategory, but is to be based upon performance levels achieved by exemplary plants. In those industrial categories where present control and treatment practices are uniformally inadequate, a higher level of control than any currently in place may be required if the technology to achieve such higher level can be practically applied by July 1, 1977. The following factors must also be taken into account in establishing best practicable control technology currently available. These are: (a) the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application; (b) the age of equipment and facilities involved; (c) the processes employed; (d) the engineering aspects of the application of various types of control techniques; (e) processes changes and (f) non-water quality environmental impact (including energy requirements). Also, this level of technology emphasizes treatment facilities at the end of the manufacturing process but it may include control technology within the process itself if it is considered to be normal practice within an industry. Also, there should be a high degree of confidence in the engineering and economic viability of this level of technology at the time of commencement of actual construction of the control facilities for it to be considered "currently available."

"Best available technology economically achievable" is to be achieved not later than July 1, 1983. This level of technology is not based upon an average of the best performance within an industrial category, but it is to be determined by identifying the best control and treatment technology employed by specific point sources within each industrial category or subcategory, or where it is readily transferable from one industry process to another, such technology may be identified as the best available technology. Also, a specific finding must be made as to the availability of control measures and practices to eliminate the discharge of pollutants, taking into account the cost of such elimination. Essentially the same factors cited above in assessing "best practicable control technology currently available" must be taken into consideration in assessing what constitutes "best available technology economically achievable" with one important exception, which is that the Act does not require that a cost benefit analysis must be made in assessing the cost of the application of the technology in relation to the effluent reduction benefits to be achieved as is required under "best practicable control technology currently available." It just requires that the cost of the application of such technology be considered. "Best available technology economically achievable" assesses the availability, in all cases, of in-process controls as well as control or additional treatment techniques employed at the end of a production process. This level of technology is the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including no discharge of pollutants. This level of technology may necessitate some industrial sponsored development work prior to its application.

"Best available demonstrated control technology" is to be achieved by new sources. The term "new sources" is defined in the Act to mean "any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance." This level of technology is to be evaluated by adding to the consideration underlying the identification of "best available technology economically achievable," a determination of what higher levels of pollution control are available through the use of improved production processes and/or treatment techniques. Thus, in addition, to considering the best in-plant and in-of-process control technology, this level of technology is to be based upon an analysis of how the level of effluent may be reduced by changing the production process itself. Alternative processes, operating methods, alternatives must be considered.

The end product of the above analysis will be the preparation and publishing of effluent limitation guidelines and new source performance standards. These guidelines and standards will contain an identification of the industrial category and subcategory covered. Effluent limitations required for each such category and subcategory will be specified. These effluent limitations and standards will be expressed in terms of (i) unit quantities per unit of material used in the industrial process or unit of product resulting from that process or (ii) concentrations, which ever shall more clearly determine the maximum degree of pollution reduction. In addition, the guidelines will specify the factors which should be taken into account in applying such effluent limitations and new source performance standards to particular plants and consequently in determining permissible effluent limitations for such plants. In addition, samplying analytical techniques and monitoring requirements will be specified.

THE FEDERAL WATER POLLUTION CONTROL RESEARCH AND DEVELOPMENT PROGRAM ON INDUSTRIAL WASTES

by

WILLIAM J. LACY*

INTRODUCTION

The Nation's industries are the largest users of water and the major factor in the continuing rise in water pollution. Industries utilize over 15 trillion gallons/year but treat less than 5 trillion. Industry uses 50% of the daily water requirements and this is expected to climb to 65% by 1989.

Conventional treatment technology is often inadequate for many types of industrial wastes. Technology must be developed and demonstrated to achieve effective and economical control of wastes from six major water-using manufacturing areas which account for more than 80% of all water used by industry. The extent of their future needs can be estimated from growth forecasts for the next decade: iron & steel 37%, chemicals 140%, pulp & paper 68%, non-ferrous metals 55%, petroleum 53% and food 35%.

The National Association of Manufacturers estimates that to achieve control of industry's water pollution, another $12 billion, or nearly 8 times the value of existing control facilities, will have to be spent by 1978. If new technology is not developed, then much of this investment will be in outmoded plants which are not capable of meeting ever-more-stringent effluent requirements.

OBJECTIVE

The objective of the industrial pollution control R&D program is to develop and demonstrate the required technology to achieve required degrees of pollution control by least cost methods for all significant industrial sources of pollution.

Presented to the Japanese Delegation to the Second U.S.-Japan Conference on Sewage Treatment Technology, Washington, D.C., December 4-8, 1972.

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PROGRAM OF WORK

The program includes all research, development and demonstration efforts necessary to resolve industrial pollution problems.

The objectives will be met by using the research and development grant mechanism, supplemented by in-house laboratory programs. The IPCP* will implement and administer demonstration projects for new and novel industrial wastewater treatment projects applicable for the majority of all significant industries. These demonstrations will include the latest developments in physical, chemical, biological and combinations of treatment methods. It is expected to develop further the cooperation of industry to participate in meaningful pollution abatement demonstrations and to increasingly demonstrate the feasibility of in-plant measures, by-product recovery, and wastewater reuse as methods to abate pollution and to reduce treatment costs.

GRANT PROGRAM-INDUSTRIAL PARTICIPATION

Industry may participate in these grant programs for the construction of permanent waste treatment facilities on industry property to develop and demonstrate a new or improved method treating industrial wastes or otherwise preventing pollution, which method shall have industry wide application. Grants so authorized may not exceed 70% of the project cost of $1,000,000.

The Federal Water Pollution Control Act, as amended, also provides grants for projects which can develop and demonstrate "new or improved methods of joint treatment systems for municipal and industrial wastes." Capital advantages are certainly possible if industries can discharge their wastes into municipal systems.

The grants program represents truly cooperative efforts; it's a cost-sharing type of contract. However, in some of EPA's research and development, the Federal Government bears the full cost contracting with appropriate non-government entities for these services. Limited funds are available for this purpose. Through the contract device, EPA can support almost any related worthwhile project under almost any type of institutional arrangement. We have the means for assisting pilot-scale demonstration and large full-scale projects.

There are two basic conditions that any project must have to receive a grant.

First, the project must have scientific and technical merit. There must be technical competence associated with the project; whether this comes from the grantee himself or by consultants which he engages, makes no difference to us.

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*The Industrial Pollution Control Program

LONG RANGE GOALS

The program goal of industrial water reuse and product (or by-product) recovery is economically, technically and philosophically sound.

The waste products must be considered an integral part of any manufacturing process and the cost of treatment of industrial wastes must be included in the pricing of the product. Waste disposal operations normally result in a net cost to the industry producing the waste. However by-product recovery and utilization techniques will reduce the cost of treatment and frequently proves to be less expensive than other methods of disposal.

Recycled water ultimately may be the most valuable product due to supply shortages increasing water supply costs, increasing water treatment costs and mounting municipal sewerage charges. The recovery of product fines, useable water and thermal energy are key methods of reducing overall waste treatment costs and must always be considered. There are many products being recovered from the solid wastes, but there are a great many more that are not currently being recovered that could be recovered.

Frequently, waste streams can be eliminated or significantly reduced by process modifications or improvements. One notable example of this is the application of the dry caustic peel process for potatoes. This measure brings about a substantial reduction in waste volume as well as a net reduction on BOD.

One of industries' principal requirements of waste treatment, by-product recovery, and water reuse is that the main product or products of the plant be satisfactory to the consumer and that the operation of the plants be efficient and economical.

Through cooperation with the EPA R&D program, industries in general are becoming more aware of the need for overall pollution control and product (or by-product) recovery. This is not only because pollution effects the environment but also because it effects the general public who are the customers. In addition, industries too depend upon our nations rivers and streams for suitable water for their manufacturing processes.

Closed-loop industrial waste water and water systems are vitally necessary to maintain continuity in future industrial expansion. The huge water use and high growth rate of water usage of American Industry cannot rely solely on traditional water supply sources. Even in water abundant areas, intake water supplies for industrial use is fast becoming restrictive. The trends toward water reuse has already been started. It must be accelerated now, if we are to provide an adequate base for future industrial expansion.

Current and future environmental standards concerning discharges of waste waters are expected to accelerate the pressure on industry to reduce both, the pollutional discharge loads, and magnitude of effluent volumes, in order to minimize impacts on the environment.

Waste water reuse is therefore not only a resource conservation measure but also a method of pollution control. It is a step in time with future demands. Adequate R&D activity in this field of exploration is the key to accelerating the implementation of extensive waste water reuse systems, and even the totally closed-loop water cycle. The latter, which result in a no effluent discharge situation, would be able to comply with any foreseeable water quality standard possible, now, or in the future.

Industrial water quality requirements for reuse are less demanding, as a general rule, than the needs for municipal supplies. Accordingly, industrial water reuse may be technically and economically achievable earlier than municipal water reuse systems.

By-product recovery of materials, other than water, and utilization of pollutants for beneficial purposes is a means to help off-set the cost of water pollution control. In addition, natural resources are conserved, and the efficiency of industrial material-to-product conversion is increased. It is potential by-products which are currently not recovered which account for the major bulk of pollutants entering our nations water ways.

The needs show that the industrial pollution control program must be primarily dedicated to the attainment of:

1. Qualifying and quantitizing industrial wastes and treatment practices.
2. Implementation of undemonstrated but feasible treatment methods to as many types of industries as possible.
3. Reduce cost of treatment by the beneficial recovery and reuse of wastewater contaminants.

Currently there are some 36 demonstration projects in the industrial pollution control program involving closed loop systems, water reuse and product recovery from the waste streams. A list of these projects and accomplishments are in Exhibit A.

WATER USE IN MANUFACTURING INDUSTRIES

Industry	Water Used (Billion Gals.)	Water Intake (Billion Gals.)	Water Discharged (Billion Gals.)	Untreated Discharge
Metals	7,672 - 21.5%	4,931	4,695	69%
Chemical	7,820 - 22.0%	3,873	3,625	85%
Pulp & Paper	6,599 - 18.5%	2,264	2,089	56%
Petroleum & Coal	7,220 - 20.3%	1,365	1,217	25%
Food	1,405 - 3.9%	818	760	76%
Machinery & Transportation	1,394 - 3.9%	567	535	90%
Stone, Clay, Glass	412 - 1.2%	251	219	83%
Textiles	1,127 - 3.2%	498	461	76%
Rubber & Plastics	1,106 - 3.1%	427	385	79%
Other	845 - 2.4%	406	314	60%
	35,600	15,400	14,300	

Note: Data from 1967 Census of Manufacturers

NATIONAL ASSOCIATION IN THE GRANT PROGRAM

* Institute of Paper Chemistry

* American Water Works Association

* National Canners' Association

* Beet Sugar Development Foundation

* Metal Finishers' Foundation

* American Iron & Steel Institute

* American Petroleum Institute

* Manufacturing Chemists Association

* American Association Textile Chemists & Colorists

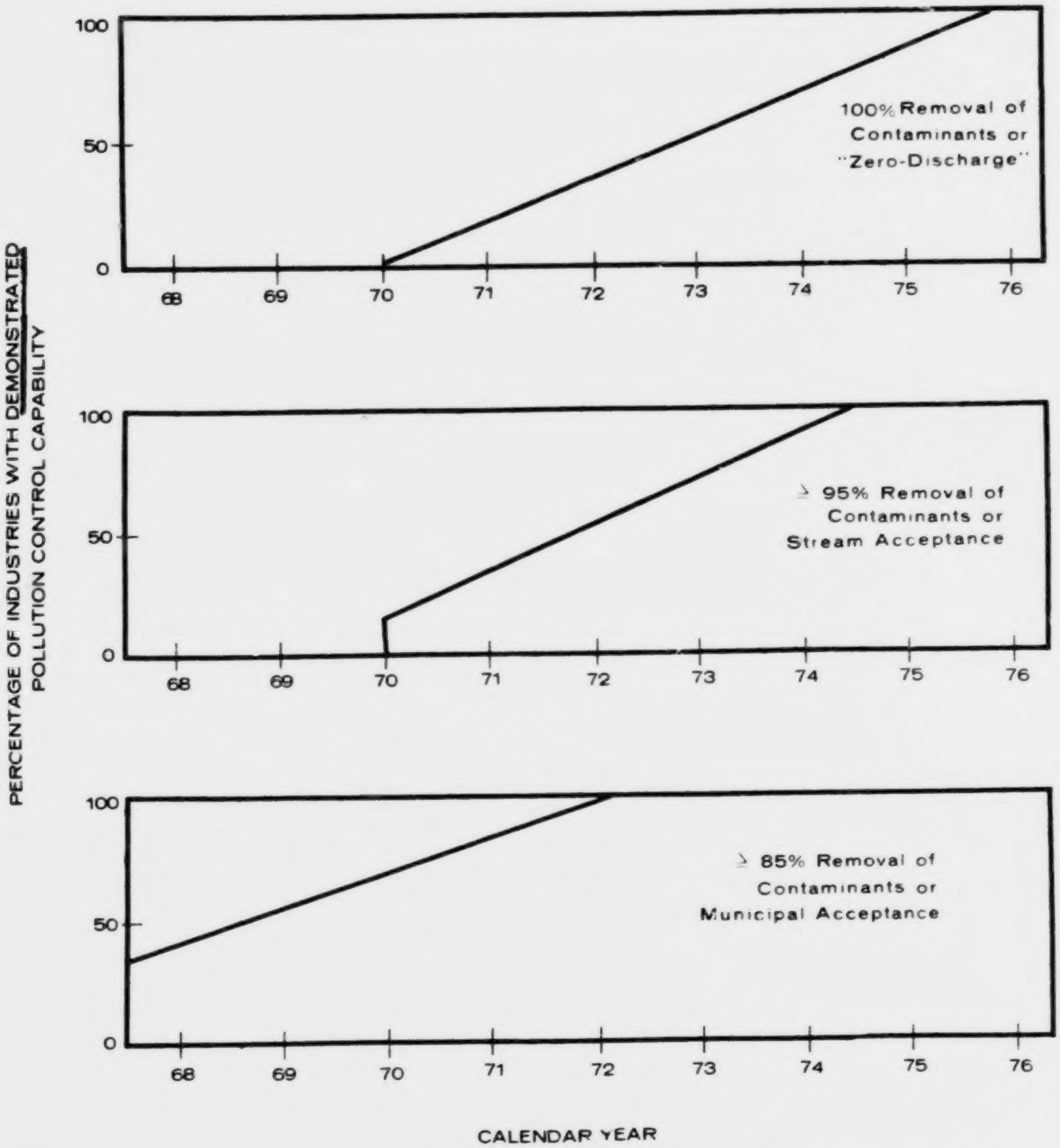
* Technical Association of the Pulp and Paper Industry

* Institute of Industrial Launderers

* American Electroplaters' Society

* National Photographic Manufacturers Association

INDUSTRIAL POLLUTION CONTROL MILESTONES*



*Based on Expenditure of Resources According to Congressional Authorization in the Clean Water Restoration Act of 1966

NEW INDUSTRIAL TREATMENT TECHNOLOGY

- 90% Removal BOD, COD, OIL - Rolling Mill Waste
- Fluid Bed Incineration - Refinery Sludges
- 95% BOD Reduction - Fruit & Citrus Processing Wastes
- Reconditioning & Reuse - Olive Processing Wastes
- Closed-loop Water System - Insulation Manufacturing
- Effluent Reuse - Synthetic Fiber Plant
- Zinc Recovery & Reuse - Rayon Mill
- 92% BOD Reduction - Plywood Glue Wastes
- 90% BOD Reduction - Tannery Wastes
- Closed-loop System - Sugar Beet Transport Waters
- 90% Color Reduction - Kraft Pulping Effluents
- 98% Color Removal - Textile Dyes
- Total Recycle - Semi Chemical Pulp & Paper
- 99% Iron Removal - HCI Pickling Rinse Waters
- Copper Recovery & Water Reuse - Copper Wire Mill Wastes
- Dry Caustic Pell of Fruit & Vegetables
- Closed Loop Ion Exchange Treatment of Fertilizer Manuf.
- 98% Acid Recovery from Steel Pickling Wastes
- 99% Phosphoric Acid Recovery & Reuse from Aluminum Finishing
- Conversion of Blood & paunch Waste to Cattle Feed Packing House Wastes
- Elimination of Water Treatment Wastes by MgCO3 recovery and Reuse - Water Treatment Plants
- 98% Recovery & Reuse of Sulfite - Tannery Wastes
- Conversion of Whey Waste to Powdered Protein Dairy Wastes

EXHIBIT A

Project No.	Title	Company	Remarks
12010 DSA	Electroplating Waste Treatment and Water Reuse	S. K. Williams	90% reuse
12010 DPF	Treatment Recovery, and Reuse of Copper Wire Mill Pickling Wastes	Volco Brass & Copper	copper & 95% reuse
12010 DRE	Pollution Control of Blast Furnace Gas Washer Through Recirculation	Interlake Steel Corp.	90% reuse
12010 DMF	Chemical Treatment of Plating Waste for Elimination of Chromium, Nickel and Metal Ions	Beaton and Corbin Mfg. Co.	67% reuse
12010 FNM	Recovery of Sulfuric Acid and Ferrous Sulfate From Waste Pickle Liquor	Fitzsimmons Steel Co., Inc.	acid recovery
12020 EAS	Demonstration of the Recondition and Reuse of Organically Contaminated Brines from Chemical Process Industries	Dow Chemical Company	95-100% reuse phenol, acetate, Cl_2 recovery
12020 DQC	Evaluation of Polymeric Materials for the Treatment and Recovery of Petrochemical Wastes	State of Louisiana	closed-loop design
12020 ERM	Ion-Exchange Effluent Treatment Unit (PET)	Mineral Pigments Corp.	ion exchange, 50% with Cr recovery
12040 FUB	Closure of Water Use Loop in NSSC Pulp and Paperboard Mill Utilizing R-O as a Unit Operation	Green Bay Packaging, Inc.	closed loop entire mill

Project No.	Title	Company	Remarks
12040 EEL	Development of Reverse Osmosis for In-Plant Treatment of Dilute Pulping Industry Wastes	Pulp Manufacturers Res. League	95-100% reuse
12040 EJU	The Production and Use of Activated Carbon for Water Renovation in Kraft Pulp and Paper Mills	St. Regis Paper Co.	conversion of by-product carbon, 90% water reuse
12040 EEK	Treatment of Selected Internal Kraft Mill Wastes in Cooling Tower	Georgia-Kraft Co.	recycle heat & water
12040 DYD	Evaluation and Demonstration of the Massive Lime Process for the Removal of Color from Kraft Pulp Mill Wastes	International Paper Co.	25% reuse & recovery
12040 FKS	Steam Stripping and Rectification of Kraft Pulp Mill Condensates and Black Liquors	Weyerhauser Co.	recovery and reuse
12040 FES	Sludge Disposal and Material Recovery System for Manufacturers of Coated and/or Filled Papers	S. D. Warren Co.	pigments recovery and reuse
12060 FDS	Elimination of Water Pollution by Packing House Animal Paunch and Blood	Beefland International Inc.	Recovery of all blood and paunch for conversion into animal feed additives by dehydration
12060 FAK	Concentration of Sugar Beet Wastes for Economic Treatment with Biological Systems	Beet Sugar Development Foundation	100% reuse of fluming wastes
12060 DXF	Development and Demonstration of an Ultrafiltration Plant for the Abatement of Pollution from Cottage Cheese Whey	Crowley's Milk Co.,	Recovery of lactose and protein from waste whey by use of ultrafiltration and R.O.
12060 EHU	Reconditioning and Reuse of Food Processing Brines	National Canners Association	Recovery of brine thru activated carbon treatment for reuse in olive storage

Project No.	Title	Company	Remarks
12050 FDK	ADM Company Waste Water Treatment	Archer Daniels Midland Co.	ion exchange
12080	Experimental Closed Water System to Eliminate Waste Water Discharge	Johns-Manville Prod. Corp.	95% water reuse with fiber recovery
12080 GCH	Granite Industry Wastewater Treatment	State of Vermont	85% reuse
12090 ESG	Zinc Precipitation and Recovery Plant	American Enka Corp.	95% Zn recovery
12090 EUX	Reuse of Plant Effluent and Cooling Water Blowdown as Process Water	Fiber Industries	25% water reuse
12120 DSG	Aerobic Biological Treatment, Sludge Dewatering and Disposal and Effluent Reuse for a Side Leather Tannery	S. B. Foots	40% reuse
12120 EPC	Removal and Recovery of Sulfide from Tannery Wastes	Blueside Tannery	sulfide recovery
12120 ESW	Develop uses in water and waste treatment of MgCO3 recovery from lime soda softening sludges	Gainesville, FL	MgCO3 by product recovery and reuse
12130 ENF	Vermont Cheese Industry Pollution Abatement	State of Vermont	Collection of all whey in the State for recovery and utilization in human and animal feed formulations
12130 FYG	Industrial Waste Water Reuse	Maryland State Dept. of Health	50% of waste water to be reused

Project No.	Title	Company	Remarks
WPRD 151-01-68	Integrated Treatment of Liquid Wastes from Food Canning Operations	National Canners Association	5% of total water used is reused by closing selected fluming operations and keeping bacterial counts down by acidification techniques
12060 EZY	Lime Treatment and In-plant Reuse of an Activated Sludge Plant Effluent in the Citrus Processing Industry	Winter Garden Citrus Products Cooperative	75 to 100% of treated effluent passed thru barometric legs of condensers
12060 EHT	Use of Fungi Imperfecti in Waste Control	North Star Research	Binch top - use of fungi imperfecti for treatment of corn and soy wastes with recovery of mycelium for feed
12060 EDZ	Pilot Plant Installation for Use of Fungi Imperfecti on Vegetable Wastes	Green Giant Co.	Pilot plant operation to verify above result on corn wastes using activated sludge and extended aeration
12060 FUR	Membrane Separation of Soybean Whey for Product Recovery and Waste Treatment	Central Soya	Ultrafiltration and reverse osmosis for recovery of protein found in waste stream. For use in human or animal feed formulations.

WASTE TREATMENT AND CONTROL IN THE METAL INDUSTRIES

E. L. DULANEY

Three broad categories of activities are included in the metals industries, these are the ferrous metals, the nonferrous metals and the metal fabrication and finishing industries.

The steel industry uses approximately 18 billion gallons of water per day or 19 percent of the total industrial water usage. Most of the water is used for non-contract cooling purposes. Approximately 2.9 billion gallons per day are used in processing operations such as coke-oven gas scrubbing, blast-furnace gas washing, basic oxygen gas scrubbing, hot rolling, pickling and rinsing, cold rolling, and dipping and other finishing operations. These operations contaminate the water with large amounts of particulate matter, oil, acid, metals, soluable salts, ammonia, cyanide, phenols, and other organic and mineral compounds. Most of the waste streams are better suited for chemical and/or physical treatment methods rather than biological methods. Pollution abatement objectives can be accomplished by process changes to reduce waste load generation, by broader application of current waste treatment technology, by increased water reuse, and/or by improving waste treatment process efficiencies at reduced cost.

The nonferrous metals industries include aluminum, copper, zinc, lead, nickel, and other metals. These industries use approximately 1.5 billion gallons of water per day. Like the steel industry the wastes are high in particulate and mineral compounds and are best treated by chemical and/or physical means.

There are over 20,000 captive and independent metal fabrication and finishing operations within the United States. The processing operations are varied and include such processes as stripping, dipping, coating (painting, etc.), electroplating, anodizing, and etching (printed circuits, chemical milling, etc.). While waste volumes are not normally large compared to the steel, paper, food processing, or petroleum industries, their frequently corrosive and highly toxic nature makes these wastes particularly hazardous. Waste treatment, usually by chemical processes, is necessary to protect sewer lines from corrosion, sewer maintenance crews from toxic gases and minerals, and receiving municipal biological treatment plants from deactivation by slugs or accumulations of toxic materials, and to protect all species that may come into contact with effluentor the receiving waters.

Until recently efforts at water pollution control in the United States were directed at attaining a "water quality" appropriate to the specific uses to be made of each segment of a stream. In principle this approach utilized the full waste assimilation capabilities of a stream, or, stated another way, this approach permitted the discharge of wastes up to the limit of the waste tolerance of a stream consistant with its intended use. Problems arose with the monitoring and the allocation of the waste assimilative capability of streams and, in fact, the "water quality" approach proved to be generally ineffective in reducing stream pollution.

More recently the EPA has embarked on a new approach to pollution abatement. This new approach consists of a combination of "effluent standards" and "water quality" standards. In principle, the new approach utilizes the waste assimilative capacity of receiving streams only to the extent necessitated by discharges from basic waste treatment facilities, and then only if such loads are not detrimental to water quality requirements. Advanced waste treatment technology must be applied if necessary to meet "water quality" standards.

The effluent standards are to be achieved by means of the requirement of waste discharge permits. These permits will allow the discharge of only that portion of the raw waste load which cannot economically be removed, and then only if the discharge load will not exceed water quality standards limitations.

The Office of Enforcement and General Counsel of the EPA, with the assistance of the Office of Air and Water Programs and the Office of Research and Monitoring, has prepared Effluent Limitation Guidance for twenty industrial categories. These guidance documents have been issued to the Regional Offices to assist them in determining the conditions and limitations to include in individual waste discharge permits. The permits will require waste treatment to the "A" level where possible and to the "B" level as a minimum under extenuating circumstances. The "A" level is considered to be the "Best Practicable Control Technology Currently Available". Where possible the limitations are based on pounds of specific pollutants discharged per unit of production.

The Office of Air and Water Programs is currently developing "Effluent Limitation Guidelines" on twenty seven industrial categories. These guidelines are to become Effluent Limitation Regulations by 1977. Technology and economics for Treatment Levels I, II, and III, roughly equivalent to Best Practicable Control Technology, Best Available Control Technology, and Standards of Performance for New Sources respectively are being developed. These guidelines and regulations will also be based on pounds of specific pollutants discharged per unit of production wherever possible.

The attached tables show the subcategorization of basic steel industry operations or waste sources, the most significant pollutant parameters to be controlled, the unit raw waste loads of these pollutants produced, treatment methods, and the percent removal achievable and required to meet the various effluent load limitations. The "B" and "A" levels are from the OEGC "Effluent Limitation Guidance" documents, the BLT (Base Level Treatment) and BAT (Best Available Treatment) are from an earlier study of the steel industry by the C.W. Rice Division of NUS (EPA Contract 68-01-0006), and the other treatment methods indicated are from ORM demonstration projects and studies.

In coke plant operations by product recovery was initially practiced for reasons of economy. Increasing competition from petrochemical companies has caused many coke plant operators to discontinue by-product recovery operations. Effluent

Limitations will provide added incentive to resume or continue by-product recovery operations. Item I(g) shows the effectiveness of by-product recovery alone in reducing waste loads. Item I(d) shows the effectiveness of by-product followed by biological treatment and recycle. Item I(f) shows the anticipated effectiveness of a demonstration project currently being installed. If this project achieves its treatment goals, then the principle area remaining for improvement will be in the achievement of these treatment levels at reduced capital and operating costs.

In the Blast Furnace area several plants are operating chemical treatment and recycle systems to achieve significant raw waste load reductions [Item II (e)]. Further improvements in the area of maintaining low blowdown rates consistantly, in treating the blowdown, and in reduction of ammonia discharges are desired.

Spent pickle liquor and pickle rinse waters are a major source of chloride and sulfate salt discharges. Highly effective pickle liquor recovery and regeneration sytems are available but not broadly utilized. Only one mill in the U.S uses hydrochloric acid pickle liquor regeneration and as Item V(e) indicates, we have yet to attain the effectiveness and economic data on this operation. One facility has shown that process design can eliminate pickle rinse discharges. The applicability of these control methods to larger operations must be determined. One sulphuric acid recovery project demonstrated the ability to eliminate spent pickle liquor discharges but there remains a problem in the disposal, usage, or conversion of the solid ferrous sulfate heptahydrate by-product.

Cold rolling oil-water emulsion wastes have been treated to achieve 90% reduction of COD and oil loads but due to the high initial concentrations the effluent loads remain excessive. Treatment methods which will recover the oil for reconstitution of the rolling emulsions, rather than as a fuel oil, may provide the potential for improved treatment economics and the development of recycle systems appears to offer good potential for further reduction of the waste loads.

The Effluent Limitation Guidance document on the steel industry presents figures for effluent limitations on additional parameters in certain subcategories but the absence of unit raw waste data precluded the calculation of percent removals as presented here. The tables illustrate the need for further sub-categorization of the industrial operations and for the development of additional information on unit raw waste loads and treatment methods effectiveness and costs.

The Effluent Limitation Guidance" on the Metal Finishing Industry pertain primarily to electroplating operations and are expressed in terms of allowable concentrations which must not be exceeded. Dilution as a means to achieve these concentrations is not permitted but at this point a basis for limiting excessive process water usage and consequent indirect dilution of effluents has yet to be developed. The development of unit raw waste load and unit effluent load limitation data, or other basis for assuring adequate treatment of electroplating wastes, are to be considered under a study contract soon to be implemented.

In the non-ferrous metals area the Effluent Limitation Guidance document applies only to the aluminum industry. Another study contract soon to be implemented will be directed toward the development of Effluent Limitation Guidelines for both the copper and the aluminum industries.

The above comments provide the potential for several areas of cooperation between Japan and the United States. The identification of steel industry waste treatment technology, currently being applied in Japan, which exceeds the treatment efficiencies indicated in the table or which achieves this effectiveness at less cost would be of great interest to the EPA. If further investigation varifies that the technology is in fact an advancement and that it has the potential for application to the industry in the U.S. we would want to pursue with you possibility of access to the facility for detailed study and analysis. This would require your further assistance in the identification of a competent impartial local contractor to perform this evaluation study for us. Additionally, if your have suggestions on a bases other than concentration limitations for assuring adequate treatment of electroplating wastes we would appreciate an opportunity to discuss that subject with you. Similar opportunities for cooperation in the non-ferrous metals area will probably develop in the future after we have had an opportunity to develop a better data base on waste treatment practice and capabilities in these industries.

CARBON STEEL INDUSTRY

WASTE TREATMENT

I COKE PLANTS		NH3	CN	Phenol	BOD	
3000 Gal/Ton	URWL*	.35	.3	.55	3.0	
			% Removals			
(a) "B": DP, SE		14	97	82	-	
(b) "A": DP, SE, Bio		43	98.3	99.9	-	
(c) BLT: VR, Fr, Fx		43	0	84	23	
(d) BAT: Fr, Fx, D, Bio, R(.8)		94	99	99.6	98.5	
(e) 3 Stage Bio		90	57	99.9	-	(1)
	URWL	1.56	.0184	.85	-	
(f) Fr, MFE, CA, VI, SI		96	100	100	-	(2)
	URWL	.890	.007	.13	-	
(g) Fr, Fx, V.R.		93	0	63	-	(3)

*Unit Raw Waste Load: pounds of pollutant produced per unit of raw material consumed or product produced. For coke plants the unit is a ton of coal coked. For the remainder of the industry the unit is a ton of product (intermediate or finished) produced in the operation.

Note: Treatment Method Symbols:

DP	Dephenolizer
SE	Solvent Extraction
Bio	Biological Treatment
VR	Vapor Recovery (Phenol Recovery)
Fr	Free Ammonia Still
Fx	Fixed Ammonia Still
Dl	Dilution (to non-lethal concentrations)
R	Recycle, and Recycle Fraction
MFE	Multiple Effect Evaporation
VI	Vapor Incineration
SI	Sludge Incineration
CA	Carbon Adsorption

II BLAST FURNACES

		NH	CN	Phenol	SS
2200 Gal/Ton	URWL	.25	.09	.02	55
		% Removals			
(a) "B": Th, Chem		20	78	50	98.4
(b) "A": Th, Chem, R(.92)		60	93	75	99.8
(c) BLT: Th		0	0	0	98
(d) BAT: Th, Chem		0	0	0	99.1
	URWL	1.06	.125	.0017	17.3
(e) Th, Chem, R(.9)		90	94	97.7	99.6(4)

Note: Additional Treatment Methods Symbols, etc:

Th	Thickener
Chem	Chemical Treatment
T Tr	Terminal Treatment

(4) EPA-ORM Grant Project 12010 DRE

III STEEL MFG.

		SS
225 Gal/Ton	URWL	30
		% Removal
(a) "B": Th, Chem		99.8
(b) "A": Th, Chem, R(.92)		99.9
(c) BLT: Th		99.4
(d) BAT: Th, Chem		99.8

IV HOT FORMING

		OIL	SS
7500 Gal/Ton	URWL	3.5	40
		% Removal	
(a) "B": SP, OS, Chem		74	95.5
(b) "A": SP, Os, Chem, F, R		97	99.7
(c) BLT: SP, OS		74	84.5
(d) BAT; SP, OS, F, R(.8)		96.5	99.4
(e) Th, Chem, MF			

Note: Additional Treatment Method Symbols etc:

SP	Scale Pit
OS	Oil Skimmer
N	Neutralization
F	Sand Filtration
MF	Magnetic Flocculation
S	Settling
PA	Polymer Addition

V COLD FINISHING

A. Pickling (Continuous)

		SS	FeD	Cl-	SO4--
	URWL	.075	.006	13	43
(a) "B": N(HCl); T. Tr(H2SO4)		-	-	0	0
(b) "A": Regeneration (HCL), n(H2SO4)		-	-	81	86

C. Cold Rolling		COD	SS	FeT	Feg	Oil
1700 Gal/Ton	URWL		2.5			4.25
(a) "B": AF, S			80			95
(b) "A": EB, AF, Ch, S			98.4			95
(c) BLT: S, OS			24			56
(d) BAT: EB, AF, R(.8)			80			98.7
(e) Chem., AF			89			91 (7)

(7) EPA-ORM Grant Project 12010 EZV

Note: Additional Treatment Method Symbols, Etc.:

AF - Air Flotation
EB - Emulsion Braker
Ix - Ion Exchange

D. Tin Plate		CN	Fe	CRT	Sn
	URWL	.05	.584	1.3	2.9
(a) "B": AF, S		40	96	99	95
(b) "A": AF, Ix, Chem		80	97	99	97

E. Galvanize		SS	CN	Fe	Cr	Oil	Zn
	URWL			.29			
(a) "B": T Tr				30			
(b) "A": Seg, Tr				93			

VI COST DATA

Coke: $.50/ton
BF: .34/ton
Pickle Rinse: .05/Ton (operating cost only)
Cold Rolling: .06/Ton (operating cost only)

RESEARCH & DEVELOPMENT PROJECTS
OF THE
INDUSTRIAL POLLUTION CONTROL SECTION
FOR THE
CHEMICAL INDUSTRY

FOR PRESENTATION AT THE

SECOND U.S. - JAPAN CONFERENCE ON SEWAGE TREATMENT TECHNOLOGY

DECEMBER 6, 1972

GEORGE REY

INDUSTRIAL POLLUTION CONTROL SECTION
BRANCH OF APPLIED SCIENCE & TECHNOLOGY
OFFICE OF RESEARCH & MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY

THE EPA R&D PROGRAM FOR ENVIRONMENTAL CONTROL IN THE U.S. AND PUERTO RICAN PETROCHEMICAL INDUSTRY

BY

PAUL E. DES ROSIERS AND GEORGE REY*

INTRODUCTION

On the formation of the National Industrial Pollution Control Council, President Nixon said, "It would be unrealistic, of course, to think that private enterprise could meet this problem alone. The problem of the environment is one area where private enterprise can do the job only if government plays its proper role."

WATER POLLUTION LEGISLATION

The Water Quality Act of 1965 provided for State water quality standards for the first time in Federal legislation. This was followed by the enactment of the Clean Water Restoration Act of 1966. The administration of the provisions of the 1966 Act is currently the responsibility of the Environmental Protection Agency, which was established on December 2, 1970.

The Clean Water Restoration Act provided not only vastly increased authorization for Federal grants for the construction of sewage plants, but also for research and demonstration of new or improved methods for municipal and industrial water pollution control.

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The Environmental Protection Agency consolidated into one agency the previous major Federal programs dealing with water, and also air and solid waste pollution, pesticides regulation, and environmental radiation.

Under provisions of the 1966 Act, the EPA has developed a research and development program for water pollution control in the Organic Chemicals Industry, which is largely petrochemical in nature. This discussion of the Federal program will hopefully indicate areas of mutual participation and cooperation, by and between, the Federal, state, municipal, and industrial communities.

The Federal program is unusual--perhaps unique in Government. It is a Research, Development and Demonstration program (RD&D). It is a coordinated, problem-solving program that is dedicated to exploratory research of new, imaginative, and improved pollution control methods. It is a program that provides for the engineering development of these methods to solve the practical problems associated with bringing an "idea" out of the laboratory and into the real world. Finally, it allows for the demonstration of this new technology to go that extra, normally neglected, step of showing the decision-makers that new and improved technology has really arrived and may be implemented.

The program is highly mission-oriented. Each of our projects responds to an identified need for an answer. These "needs" are identified and assigned priority primarily through input from the non-research elements of the EPA and from industry. Briefly, we are trying to respond to the real needs for the Agency and industry.

Within the Organic Chemicals Industry, for instance, it would be desirous if the various trade associations representing the industries coordinate the member companies' statements of need for input into the EPA R&D program. This type of cooperative effort has been the cornerstone to a relevant effort in other industrial EPA R&D programs and should prove most beneficial to the customer - the members of the Organic Chemicals Industry and the general public.

The program is unique because for the first time, industry may now participate in grant programs to develop and demonstrate new or improved methods for treatment of industrial wastes or otherwise preventing pollution, which shall have industry-wide application. Grants so authorized may not exceed 70 percent of the project cost, and are limited to a maximum of $1 million.

The Federal Water Pollution Control Act, as amended, also provides grants for projects that can develop and demonstrate "new or improved methods of jointly treating municipal and industrial wastes." Capital advantages may be possible in some cases if industries can discharge their wastes into municipal systems.

The grant programs represent truly cooperative efforts; they entail cost-sharing types of agreements. In some cases, the Federal Government may bear the full cost of R&D by contracting with appropriate non-government entities for special services; however, limited funds are available for this purpose.

Obviously with these tools the EPA can support almost any related worthwhile project under almost any type of institutional arrangement. We have the means for sponsoring research, assisting pilot-scale developments, and for participating in large (full-scale) demonstration projects.

To receive a grant several conditions must be met: (1) the project must have technical merit; (2) there must be technical competence associated with the proposed project, either as provided by the grantee himself or by consultants that he employs; and (3) the project must fulfill an identified need. This means it must usefully demonstrate a way to combat water pollution. Furthermore, the results obtained must be accurate with respect to costs and performance, and they must be made available to the public.

WATER POLLUTION NEEDS OF THE ORGANIC CHEMICALS INDUSTRY

Let us define wastes, for the moment, as misplaced resources of human industry. I say momentarily, because all wastes have use in some time frame and in some ecosystem. The time frame is impacted by technology and need. Time, need, place, and technology then, all determine the scope of industrial wastes problems. Yesterday's moldy bread is today's penicillin. Last month's paper mill wastes could be in tomorrow's road binding materials, cooking sauces, medicinals, or activated carbon. Pollutants may therefore be considered as the wrong substances in the wrong places at the right time.

Industrial wastes are the nation's principal point sources of controllable waterborne wastes. In terms of the generally quoted measurements of strength and volume, the gross wastes of manufacturing establishments are about three times greater than those of the nation's sewered pollution. Moreover, the rate of industrial production, which gives rise to industrial wastes, is increasing at about 4.5 percent per year or three times faster than the population growth rate. Add to this the extensive variations of composition of industrial wastes, and one realizes that the solution to industrial water pollution control is not a simple one.

Some industries are currently discharging their wastes to municipal treatment systems. These systems for handling combined municipal and industrial wastes, in many cases, may likely provide the means for attaining adequate water pollution control most effectively and least expensively. The extent to which these joint handling systems will increase over the near future will depend largely upon the managerial ability of municipal and industrial officials and their willingness to enter into cooperative arrangements. It will also depend on the compatability of the wastes for joint treatment and other factors, such as the proper siting of the facilities. The costs that industrial establishments will be required to incur to use municipally-operated facilities will also be a factor. Assuming appropriate charges, establishment of pretreatment requirements, and that joint treatment facilities are designed and operated effectively, the use of such facilities by industry may well lower overall pollution control costs for both institutions.

Some large industrial plants in the United States treat their wastes economically. However, the use of the same technology may not be economical for the treatment of wastes produced in similar but smaller plants. At present, some small plants discharge their wastes to the community sewer system and depend upon the municipal sewage plant for the treatment. However, some plants do not have sewer systems readily available and thus must provide their own treatment facilities. Moreover, appropriate systems for some industrial wastes have not yet been developed. It thus becomes imperative that methods for the treatment or control of wastes be developed, where necessary, by industry with consideration being given to the following:

1. Many municipal sewage plants are presently overloaded and sensitive to strong and/or toxic industrial wastes and thus may be forced to restrict the types of industrial plant wastes discharged untreated to the sewage system.
2. Certain industrial wastes may well be an undeveloped national resource, as wastes often contain valuable by-product materials, some of which could more feasibily be recovered than treated.

Ideally, a process for treating wastes from an industry should:

1. Effect the removal of the pollutant at minimum cost.
2. Provide for the economical recovery of any valuable by- or co-products.
3. Comprise a technique that would permit the recycling of recovered materials, including water, back to the production operation.
4. Be simple and require minimum operating labor.
5. Require relatively low capital investment.

Reduction of industrial waste discharges is often accomplished efficiently and economically by process modifications, improved housekeeping, and reuse/recycle water management practices. During the period 1954-1968, total water use by all U.S. industries increased 70 percent, but water intake only increased 34 percent (see Table 1). All U.S. industries achieved a reuse ratio of 2.30 in 1968. By contrast, the Organic Chemicals Industry (which includes the petrochemical industry and is categorized herein by SIC 2815: Cyclic Intermediates and Crudes, and SIC 2818: Industrial Organic Chemicals, n.e.c.) had a reuse ratio of 1.90 in 1968, a net decrease of 4 percent over that of the 1964 census. Although the total water usage increased only 20 percent, water intake increased 25 percent, indicating an ineffective utilization by this industry of potential recyled water and/or multiple use of water. In comparison, a related industry, petroleum refining, has achieved an average reuse ratio of 5.25 in 1968, an increase of 63 percent since 1954.

In 1964, industry produced 13.1 trillion gallons of wastewater, compared to 5.3 trillion gallons for the sewered population of the U.S. (3). In terms of process water use only, in 1964, industry alone handled as much water as was needed for 63 percent of all domestic comsumption (4). It would appear that extensive wastewater reuse by industry should therefore have a substantial impact on water conservation in the U.S. This is of particular significance now in water shortage areas, and in the future in water abundant areas.

Although water reuse has remained essentially constant during 1964-1968 for the Organic Chemicals Industry, absolute and substantial increases in the reuse ratio are potentially possible under appropriate circumstances. Past occurences of water reuse have been motivated by the pressures of limited water supply, poor water quality, and more recently, environmental considerations. The latter, particularly in view of forthcoming legislation, should accelerate the trend in the near future.

Now, let us speak more explicitly of the petrochemical industry, by far the largest segment of the Organic Chemical Industries. As we know, the term petrochemicals applies to those chemical products derived from petroleum fractions and by-products or from natural gas constituents (5). A modern petrochemical complex consists of "a complicated design comprising many process units, most of which are capable of considerable variation in processing yields or product qualities and which have available an assortment of potential charge stocks, many of which can be converted into different sets of products by several of the different process units" (6). The major sources of pollution in the petrochemical industry may be delineated as follows (7):

a. Crude oil processing

b. Steam distillation

c. Steam stripping

d. Product rinses

e. Barometric condensers

f. Catalyst regeneration

g. Partial pressure reduction with dilution steam

h. Boiler and cooling tower blowdowns

i. Contaminated area drainage - runoff

j. Water treatment - special additives

k. Oil storage and transfer

l. Vessel clean-outs

m. Unrecovered reaction products (by-products and co-products)

n. Process leaks, spills, purges, etc.

o. Inorganic chemical production of acids, halogens, and nitrogenous salts.

Such wastewaters may contain various salts, acids and alkalies, ammonia, sulfides, solids, and mixtures of organics of varying biodegradability, phenols and other taste and odor producing chemicals, and heavy and light oils. Furthermore, wastewaters so generated typically exhibit a BOD and COD range of 100 to 10,000 mg/l and 200 to 15,000 mg/l, respectively, with an average of 1,150 mg/l BOD and 3,100 mg/l, COD (8)(9), which is indicative of the strength of the wastewaters. In Table 2 are listed some typical wastewater characteristics resulting from the production of a variety of petrochemicals.

Recently, the Manufacturing Chemists Association conducted a survey of the Inorganic, Organic, and Plastics Manufacturing Industries to obtain information on the wastewater characteristics and treatment technology presently being utilized (11). Bio-treatment was considered the tentative norm of technology presently being practiced, with 15 plants performing secondary treatment of the 71 plants reporting. The data presented in Table 3 pertain to the performance currently being achieved by some of the most efficient bio-processes for treatment of organic wastewaters reported in the survey. These were considered to be representative integrated facilities producing high volume organic intermediates/feedstocks that furnished usable bio-treatment data.

In the near future, the EPA will publish Effluent Limitation Guidance for the Petroleum Refining Industry. Based upon a classification system devised by the American Petroleum Institute (API), refineries were divided into five classes depending upon varying degrees of processing complexity:

Classification	Refinery Type
A	Crude topping
B	Topping and cracking and/or reforming
C	Topping and cracking and petrochemicals
D	"B" Category and lube oil processing
E	"D" Category and petrochemicals

Petrochemicals, as defined above, related to refinery operations and included all first generation conventional refinery-associated production such as naphthalenes, benzene, toluene, xylenes, C_4 hydrocarbons, ethylene, acetylene, etc. In order to qualify as a Class "C" or "E" refinery, petrochemical manufacture must be demonstrated, to include some or all of these primary petrochemicals.

Table 4 depicts the potential effluent limitation guidelines* for a Class "E" refinery. Column C represents effluent concentration limits for conventional secondary treatment equivalent to aerobic/anaerobic ponds and/or lagoons, including related treatment efficiencies. Column B delineates the minimum acceptable treatment as compared to Column A where the best practicable treatment (BPT) has been equated to the most efficient bio-treatment technology presently in use by the Class "E" plants. Column D represents typical effluent concentrations achievable using activated carbon tertiary treatment. It can be seen that, in order to meet the BPT limits, some plants may need to incorporate AWT systems into their treatment scheme. Moreover, an even more severe constraint on the treatment of petrochemical wastewaters from the producers of secondary and intermediate petrochemicals becomes apparent if one evaluates the nature of the waste to be treated - that of its relative biodegradability and normally higher strength. Figure 1 is an empirical diagrammatic representation of the biodegradability of wastes encountered in this portion of petrochemical industry. Organics in general and petrochemicals in particular may be characterized typically as to their respective abilities to degrade biochemically: Type (a) classical log growth curve, similar to domestic waste; Type (b) requiring a longer lag

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* For discussion purposes only. Should not be construed as official or proposed guidelines.

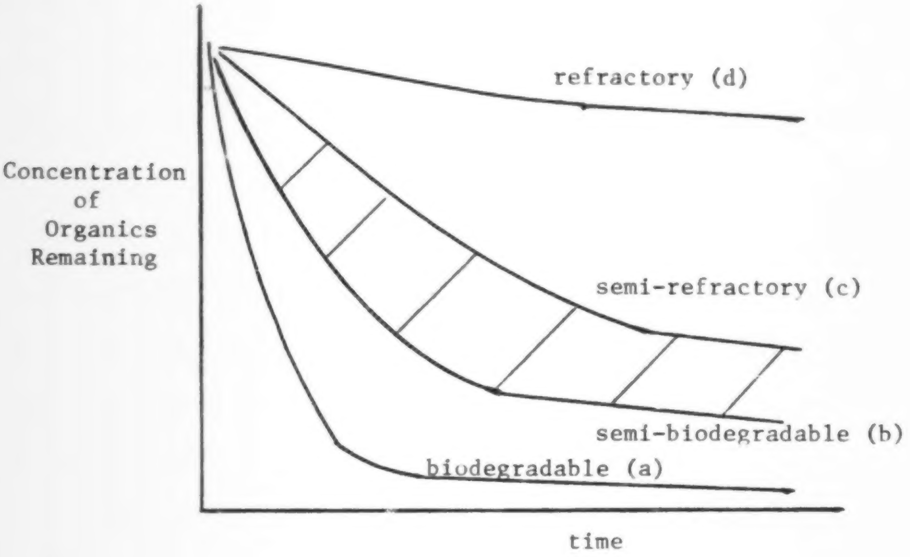

Figure 1. Types of Petrochemical Wastewaters and Their Relative Biodegradability.

or retention time for the enzymatic systems of the microorganisms to become more fully developed - a semi-biodegradable waste; Type (c) a long period of "seed" acclimation required before assimilation of organics proceeds - a semi-refractory waste; and Type (d) essentially no biochemical action due to a refractory waste. Petrochemical wastewaters generally fall into the range of a Type (b) - Type (c) waste as depicted by the cross-hatched area in Figure 1. Several explanations have been postulated for this anomalous behavior (16): (a) reaction rates of individual components (organics) may differ markedly, (b) the bio-mass present may not utilize some of the constituents due to the absence of the proper enzymes (catabolic and biosynthetic enzymes and permeases must all be present in proper concentrations), and (c) there may exist materials causing inhibition or repression (interference in the natural metabolic pathway). An additional factor that must be taken into account, and one that may be the most significant, is the formation of intermediates and end-products of metabolic pathways that diffuse out of or are released by cell lysis - these products may exhibit a profound effect on the biodegradability of the waste. Extracellular quantities of these intermediates and metabolites often are indistinguishable from the original waste components, and due to the non-specificity of either the BOD or COD analysis, such a change in concentration cannot be monitored directly and "a waste which is biodegradable may appear to be 'hard' because of intermediates which have passed into the medium during the given detention time" (16, p. R488). Table 5 contains a list of 34 organic compounds found to be bio-refractory (17). Similar compounds have been identified in the municipal raw water intakes

(Mississippi River and tributaries) and/or finished water supplies at or near New Orleans, Louisiana (18). Therefore, it is apparent from the previous discussion that petrochemical waste treatment practices present the environmental/chemical design engineer with a formidable challenge.

In addition to wastewater treatment technology, all industries have inherent pollution control concerns with process sludges, waste chemicals, and thermal discharges in the form of cooling waters. The question of toxic, hazardous, and/or taste, odor, and tainting constituents in discharges of any sort must also be confronted.

A method of controlling warm water discharge is by use of cooling towers or ponds with provisions for the cooled water to be reused. Table 1 showed the increase in water intake and total use for U.S. industry over a 14 year period. Apparently, the water reuse trend in industry is increasing, however, it is not particularly dramatic for the Organic Chemicals Industry as compared to the Petroleum Refining Industry.

There are indications that industry is well aware of the benefits of recycling cooling tower blowdowns (19). One such example concerns a Class E" refinery where "the cooling towers are used to reduce the concentration of organics and to concentrate the undesirable precipitates. Thus all wastewaters originating from plant operations and storm water runoff are either recycled into the process stream and reused or recycled in the cooling towers" (20, p. 242). If wastewater reuse is developed and implemented to its maximum potential, it could provide industry with a viable technique for pollution control, which could conceivably be the least expensive alternative for fulfilling future regulatory requirements. In fact, if no discharges of wastewater are achievable and practicable, the need to obtain a permit to discharge effluents would be precluded. Add to this the water conservation aspect and the potential savings resulting from reduced effluent monitoring, and the total recycle concept has even greater appeal.

From the data presented, it may be concluded that pollution control technology in the Organic Chemicals Industry can be improved upon. Considering the characteristics of the wastewaters, the nature of the individual plants, the current state of the art relative to treatment and control practices, and the varying treatment requirements with time, and as the need for water reuse increases, it becomes obvious that several areas of R&D must be pursued in order to provide industry with the tools necessary to meet the environmental requirements of current and anticipated legislation.

WATER POLLUTION CONTROL TECHNOLOGY

Table 6 illustrates the technological areas that are, in general, pertinent to effective pollution control for the Organic Chemicals Industry. The specific solutions available to each plant will be determined by several factors - and economics (overall economics) will oftentimes be the most important of these. By and large, one must recognize the need to detoxify and/or degrade toxic wastes, control discharges of nutrients and salts (possibly through by-product recovery techniques), and reduce or eliminate inadvertent high strength wastewater releases to quantities that produce little or no ecological effects on receiving streams. Where the receiving waters are too sensitive to any permissible waste discharge, the development and implementation of "no discharge" systems of pollution control may be required as the means to meet local or national environmental standards (presently and in the future).

The wastewater treatment methods presently employed by the petrochemical industry may be classified as follows: (1) disposal by dilution methods, (2) process improvements and modification, including waste stream segregation for specialized treatment prior to final treatment, (3) bio-treatment consisting of both single- and multi-stage aerobic and anaerobic systems in series or parallel operation, (4) physical treatment methods, (5) chemical treatment methods, (6) joint industrial/municipal treatment, and (7) limited water recycle and reuse (8)(9)(17)(21)(22)(23)(24)(25)(26).

Advanced and lower cost methods of control will, of necessity, continue to be developed and demonstrated. Improving performance and upgrading existing treatment technology in conjunction with supplemental AWT physico-chemical add-on processes (i.e., tertiary treatment) may be necessary, particularly for special side streams difficult to treat by biological methods, as well as alternative methods for implementation by both old and new facilities. Sludges and chemical wastes, specific pollutants (e.g., halogenated hydrocarbons, heavy and toxic metals, etc.), and comprehensive water pollution control methods, including regionalization, also must be further developed and improved.

As a result of the EPA perspective of the state of the art, the Industrial Pollution Control program developed to date in the Organic Chemicals Industry is depicted in Table 7. During a 4 year period, a total of 26 grants/contracts have been awarded covering RD&D projects concerned with wastewater characterization and treatment costs, base level of treatment (biox), advanced waste treatment applications, and recovery (by-product and recycle/reuse) techniques. EPA support amounted to $5,078,900 or 47 percent of total estimated project costs of $10,786,700.

One recently completed development project (Project No. 12020 EEQ) resulted in the successful operation of a completely mixed activated sludge process for treatment of a propylene glycol process wastewater This wastewater was characterized by a high salt content (8-10% NaCl), a pH **of** 11-12, relatively high concentrations of the glycol (500-1,000 mg/l), together with small quantities of related reaction products (in concentrations amounting to less than 100 mg/l), namely, the oxide, the dichloride, the chlorohydrin, the chlorinated ether, and some acetol and acetic acid. A unique mixed culture, which tolerates high salt content and utilizes glycols as the only carbon source, was developed; however, an acclimation period of 6 to 8 weeks was required. TOD removal efficiencies of over 90 percent were obtained at retention times of 8.0 to 9.0 hours and loadings of 2.0 to 3.0 lbs TOD/lb MLVSS-day. Based upon such favorable results and the demonstration of the consistent reliability of the TOD and TOC parameters for correct interpretation of the behavior and fate of the organics in the wastewaters and for the evaluation of the treatment process, a subsequent grant was awarded (Project No. 800766) to develop control systems such that an activated sludge process could be operated as efficiently as a chemical process on a continuous basis, the premise being that the performance of an activated sludge process can be further improved and its reliability increased under steady state conditions. Such conditions can only be achieved by instrumentation to control: (1) the food to microorganism ratio (F/M ratio or lbs TOD/lb MLVSS) in the aeration vessel: (2) the nitrogen and phosphorus requirements; and (3) the biomass/organics reaction temperature. An additional requirement included the development of a dependable biological toxin detector to sense and eliminate (through proper feed forward and feed backward controls, the influent wastewater may be temporarily diverted to a holding basin) a toxic substance prior to its entry into the aeration basin.

Another geographical area of high program interest is the lower Mississippi River in Louisiana. The lower Mississippi River has been the site of a rapidly expanding chemical and petrochemical industry during the last 15 years. More than 60 major industries are located between St. Francisville (upriver from North Baton Rouge) and the Belle Chasse-Scarsdale free ferry crossing at New Orleans. These industries, in the main, are chemical or allied industries, petroleum refining, sugar, rubber, paper, metals, etc. The Mississippi provides a large volume of water for process, cooling, and potable use and serves as a convenient receiving stream for the disposal of wastes. Industries alone use and discharge up to 13 billion gallons of river water daily. In this water is contained over 40 million pounds of inorganic material and approximately 1 million pounds of organic wastes; this, in view of the fact that the Mississippi River supplies drinking water for over 1.5 million people in the lower river region or about half the total population of the State of Louisiana. Paralleling the rapid industrial development along the lower reaches of the Mississippi, especially during the last 10 years, the problem of undesirable taste and odor in water supplies downriver of Baton Rouge has become increasingly evident. Fish caught along this stretch of the river have become foul-tasting and unacceptable to the public because of tastes that may be described as "oily" or "chemical" in nature. Commercial as well as sport fishing in the lower river have been eliminated. Fresh water shrimp are no longer indigenous to the area. Also, many foods and beverages are now prepared with the use of "bottled" water to negate adverse effects of "potable" river water on the product. In view of the previous information, it is not surprising that complex analytical techniques have resulted in the identification of more than 30 individual organic compounds in the New Orleans finished water supply (18). Based upon such a critical need for specialized treatment technology, a grant was awarded to the State of Louisiana, Department of Commerce and Industry (Project No. 800773) to investigate and demonstrate AWT procedures for the reduction of refractory, taste and odor, and other chemical contaminants in petrochemical plant waste effluent streams. The waste quantities to be reduced are to include halogenated hydrocarbons and other refractory compounds that were found to affect water supplies, and aquatic and marine life in the lower Mississippi River with respect to taste, tainting, and odor. An economical source of activated carbon from a waste petroleum-based carbon by-product stream is to be developed. Those refractory compounds posing a hazard in current and projected concentrations, together with the effects of industrial growth on stream quality, are to be quantitatively identified and defined. The basic program will entail the necessary engineering, analytical, and laboratory studies to determine the treatment process/operations that are most applicable for utilization by each petrochemical plant participating in the project. The processes/operations to be investigated (individually or in combination) include biological oxidation, solvent extraction, carbon adsorption, and ozonation.

As one can readily see, more recently, efforts are being directed towards the development and evaluation of improved physico-chemical techniques, both for pretreatment, special segregated side streams, and tertiary treatment supplementation for, or as alternatives to, biological systems. Also, the emphasis continues to be placed upon closed-loop water reuse technology and by-product recovery. And this brings us to the EPA Industrial Pollution Control program for the Puerto Rican petrochemical industry. There exists today in the Tallaboa-Guayanilla Bay area of southwestern Puerto Rico, a large integrated refinery/petrochemical complex, including an electrical generating facility. The cumulative wastewater discharge exceeds 440 MGD (cooling, process, and boiler feed blowdowns) (see Table 8), which includes excess heat, organic matter, suspended solids, total nitrogen and ammonia, oil and grease, and phenol. The petrochemical complex produces 775 million #/yr of ethylene and derivative products, including butadiene, ethylene oxide, phenol, cumene, polyethylene, bisphenol-A, plasticizers, refined ethylene and diethylene glycols, ethyl-hexanol, isobutanol, and butanol (27)(28); whereas the integrated refinery processes approximately 175,000 bbls/day of crudes for the production of aviation and motor gasoline, jet fuel, kerosene, diesel fuel, etc., together with benzene, toluene, xylenes, cyclohexane, isobutanol,propylene and ethylene (27).

Wastewater characteristics of the refinery submerged outfall/effluent and the petrochemical complex sea intake/main effluent are delineated in Table 9. It should be noted that a large percentage of the total wastewater flow is cooling water (see Table 8). A grant application for a water reuse project has been received and reviewed favorable by the EPA. The demonstration phase of the proposed study, which entails the utilization of an optimized AWT system that will deliver treated water for use in heat transfer systems, will be conducted at Ponce, Puerto Rico. One of the major objectives of this project will be to provide quality criteria for water usage in the petrochemical industry, including quality criteria that are limiting factors with respect to reuse of renovated wastewaters, namely, boiler-feed water, cooling water, service water, and process water.

The project site is of particular interest because it represents a $350 million invested capital outlay in a petrochemical complex typical of the industry and located in an arid area. Water is thus at a premium and large quantities are available only from the sea or from ground water sources. There also exists to the west, near La Paguera, a region termed Phosphorescent Bay, a renowned tourist attraction. In recent years, the biota present therein have decreased in measurable numbers due, in part, to organic pollution discharged into the Tallaboa-Guayanilla Bay areas by the industries located nearby. The successful completion of this project will therefore have immediate and obvious impact on the environment of south central and western Puerto Rico, and it is anticipated that the results should show that a significant step can be achieved towards total recycle and reuse of petrochemical wastewaters.

The main objective of total water pollution containment within an Organic Chemicals Industrial complex is based on the concept that water pollution abatement and water conservation are economically compatable, particularly for the long term. As water availability becomes more critical, the reuse of water will be dictated by economics, with attendant inherent treatment costs merely a normal operating expense. The EPA RD&D program is, therefore, moving to provide industry with the tools necessary to implement and to accelerate the water reuse trend.

Conclusion

The Research, Development, and Demonstration grants program of EPA has been implemented to meet current and emerging needs for water pollution control in the Organic Chemicals Industry.

Since the trend toward water reuse has already commenced (e.g., the petroleum refining industry), the exception occuring in some areas of the Organic Chemicals Industry, acceleration of the trend would provide a sound basis for future industrial expansion. Since current and future environmental standards are expected to increase greatly the pressures to reduce dramatically, or eliminate altogether, pollutional loads and effluent discharges, reuse and recycle to the point of providing an industrial closed water cycle should be planned. On this point, please note that pending Federal legislation calls for the elimination of the discharge of pollutants into navigable waters by 1985, as a goal.

Specific approaches that the Organic Chemicals Industry should consider in order to achieve higher levels of water pollution control performance include:

(1) Reduction and/or elimination of once-thru water use.

(2) Reduction and/or elimination of high polluting (i.e., direct contact) water use.

(3) Recovery of products and by-products from concentrated wastewater streams.

(4) Cooling and process water recycle, and in some cases, boiler blowdown recycle/reuse.

(5) Acceptable disposition of solids, sludges, and gaseous wastes.

(6) In-plant segregation of refractory or bio-toxic organic waste streams for special AWT treatment.

TABLE 1. WATER USE IN MANUFACTURING INDUSTRIES, bgy (1)(2).

Year		Gross Water Used	Water Intake	Water Discharge	Reuse Ratio
1968	All U.S. Industry	35,701	15,467	14,276	2.30
1954		21,042	11,570	10,789	1.90
% increase (1954 - 1968)		70	34	32	21
1968	Organic Chemicals Industry*	4,331	2,279	2,162	1.90
1964		3,600	1,819	1,763	1.98
% increase (1964 - 1968)		20	25	23	-4 (decrease)
1968	Petroleum and Coal Products Industry	7,220	1,370	-	5.25
1954		4,150	1,250	-	3.22
% increase		74	10	-	63

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* Includes SIC 2815: Cyclic Intermediates and Crudes, and SIC 2818; Industrial Organic Chemicals, n.e.c.

TABLE 2. TYPICAL PETROCHEMICAL WASTEWATER CHARACTERISTICS (9)(10).

Petrochemical Principal Products	Waste Flow mgd	BOD mg/1	COD mg/1	SS mg/1
Phenol, Ethylene	2.0	300	1,200	300
Acrylonitrile	0.302	-	1,200	239
Fatty Acids, Esters, Glycerol	0.10	10,000	14,000	-
Azo & Anthraquinone dyes	0.94	352	1,760	152
Ethylene, Alcohols, Phenol	5.9	1,700	3,600	610
Acrylonitrile, Acetonitrile, Hydrogen Cyanide	3.9	390	830	106
Butadiene,Alkalate,MEK,Styrene, Maleic Anhydride	2.0	1,870	-	10
Butadiene,Maleic Acid,Fumaric Acid, Tetrahydrophthalic Anhydride	3.605	959	1,525	-
Phenols	0.215	6,600	13,200	-
Acids, Formaldehyde, Acetone, Methanol, Ketones, Nitric Acid, Nylon Salt, Vinyl Acetate, Acetaldehyde	3.46	530	10,130	160
Isocyanates.Polyols,Urethane Foam	0.57	421	1,200	50
Acetaldehyde	1.15	20,000	50,000	200
Ethylene,Propylene,Butadiene, Alpha Olefins,Polyethylenes	0.750	155	380	120
Butylene Isomers, Butadiene, Maleic Anhydride,Fumaric Acid,Tetrahydrophthalic Anhydride,Alkalate,Aldehydes, Alcohols	1.50	1,960	2,980	-

TABLE 3. BEST PRACTICED TREATMENT OF ORGANIC-LADEN WASTEWATERS (11).

Treatment Type	Flow mgd	Treatment Effectiveness Percent Removal BOD	 COD
Activated Sludge	6.6	90.0	44.5
Activated Sludge (design)	1.89	92.0	80.0
Activated Sludge	1.5	97.0	92.5
Activated Sludge/Aerated Lagoon	1.5	99.0	98.0
Aerated Lagoon	7.5	75.5	42.0
Stabilization Ponds	2.19	83.5	86.0
Trickling Filter/Activated Sludge	0.007	-	66.0

TABLE 4. POTENTIAL EFFLUENT LIMITATION GUIDELINES** FOR CLASS "E" REFINERIES.

Parameter	Effluent Limitation, mg/l (12)		Applicable Technology		
	Best Practicable Treatment (A)	Minimum Acceptable Treatment (B)	Secondary Bio-Treatment (C) (13)		AWT Systems* (D)(13)(14)(15)
NH_3-N	10.0	37.0	-	-	12
TOC	36.0	49.0	-	-	10
BOD_5	22.0	35.0	30	(80-85)	5
COD	137.0	193.0	150	(60-65)	30
Oil and grease	10.0	15.0	10	(70-75)	2
Phenol	0.1	0.5	0.3	(90-95)	0.02
Sulfide	0.17	1.0	0.3	(95-97)	0.3
Suspended Solids	20.0	40.0	40	(55-60)	10

Values in ( ) represent removal efficiency, %.

*Activated Carbon Systems.

** See footnote pg. 10.

TABLE 5. REFRACTORY INDUSTRIAL WASTES (17).

*nitrobenzene
trichloroethane
tetrachloroethylene
chloroethyl ether
chloromethyl ethyl ether
chloropyridine
chloronitrobenzene
dichloroethyl ether
*benzene
*toluene
camphor
veratrole (1,2-dimethoxy benzene)
guaiacol (methoxy phenol)
borneol (bornyl alcohol)
isoborneol
*ethylene dichloride
chlorobenzene
bromobenzene
dichlorobenzene
bromochlorobenzene
*ethylbenzene
chloroform
*styrene
isopropylbenzene
butylbenzene
dibromobenzene
*isocyanic acid
*methylchloride
bromophenylphenyl ether
*dinitrotoluene
methylbiphenyl
acetone
2-ethylhexanol
2-benzothiozole

*These compounds also have been found to impart taste and odor to drinking water supplies in trace amounts (18).

TABLE 6. POLLUTION CONTROL TECHNOLOGY STATUS IN THE PETROCHEMICAL INDUSTRY.

Technology	NEED FOR			Applications & Objectives
	Research	Development	Demonstration	
Biological oxidation	some	some	yes	(1) Multi-stage biox systems (2) To achieve and maintain 90-95 % BOD_u removal for single stage systems. (3) Need pre- and post-treatment process/operations to improve performance and reliability of both single- and multi-stage Biox.
Sludge disposal	yes	yes	yes	(1) Solids disposal: a) Land assimulation b) Incineration (fuel value) c) Catalylic oxidation d) Solvent extraction e) Wet oxidation and pyrolysis
Advanced treatment	yes	yes	yes	(1) Biox alternatives (2) To achieve and maintain 95-99% pollutant reductions (3) By- and co-product recovery (4) Refractory organic removal (5) Biox supplement
Closed loop systems	yes	yes	yes	(1) No discharge (closed cycled systems) (2) Cost of water (3) Water conservation and reuse (4) Containment of trace toxic chemicals
Comprehensive approach	-	yes	yes	(1) Total environmental effects (2) Basin planning (3) Joint treatment (4) Synergistic benefits

TABLE 7. EPA RD&D GRANTS FOR POLLUTION CONTROL IN THE ORGANIC CHEMICALS INDUSTRIES (see Appendix)

Grantee	Total Cost ($1,000)	EPA Grant ($1,000)	Primary Effort R	Primary Effort DV	Primary Effort DM	Technological Objectives
C.W. Rice**	56.3	56.3	X			Treatment costs-general
Engineering Science**	11.2	11.2	X			Wastewater characteristics
Engineering Science**	17.0	17.0	X			State of the Art
E.I. du Pont	874.5	150.1	X			Ocean dispersal of salt wast
State of Louisiana	69.0	48.3	X			Recovery: Membrane systems
MCA	60.0	42.0	X			Effects of Cl_2 on treated organics
Union Carbide	67.1	46.9	X	X		*Biox: Anaerobic inhibitors
State of Louisiana	67.3	32.5	X			Concentration of wastes by dialysis
Datagraphics*	6.7	6.7	X			Treatment costs-organics
Univ. of California	86.7	81.2	X			Recovery: Volatile solvent extraction of organics
Texas A&M Univ.	38.5	34.9	X			Recovery: Solvent extraction
Univ. of Missouri	38.5	36.4	X			AWT: Carbon sorption & regeneration
Ga. Tech.	76.1	71.4	X			AWT: Radiation treatment of high strength chlorocarbon wastes
Union Carbide	314.9	220.4		X	X	*Biox: Refractory organic wastes
Dow Chemical	282.5	197.7		X		Biox: Polvhydric/saline wastes
Celanese	600.0	395.3		X		Biox: Chloraldehyde wastes
Dow Chemical	226.6	142.3		X		Biox: Optimization thru automation
State of Louisiana	827.6	457.8	X	X		AWT: Refractory chlorocarbon wastes
Dow Chemical	196.4	108.3		X		AWT: UV Cl_2 of organic acids in waste brines
Delaware R.B.C.	995.7	646.7		X		AWT: Joint industrial/municipal wastes
	554.1	231.8		X		Recovery: Cooling water blowdowns
B.F. Goodrich	823.1	364.9			X	Biox: PVC wastes
Dow Chemical	1300.4	509.8			X	AWT: Phenol/Acetic acid waste brines
State of Alabama	989.5	314.5			X	Deep well disposal of waste
CIBA - Geigy	1268.3	392.6			X	*Biox: Plastic media trickling filters
General Tire & Rubber	938.7	461.9			X	Recovery: Distillation for renovation
TOTALS	10786.7	5078.9				

**Contract *Multi-stage systems

TABLE 8. PRIMARY WASTE LOADS IN THE TALLABOA-GUAYANILLA BAY AREAS (27).

Parameter	Class "C" Refinery	Petrochemical Complex	Steam Plant
Cooling Water, gpm	(65,000)	54,000	181,400
Process Wastewater,gpm	(4,800)	700	-
Temperature Rise, °F	-	9.7	19-20
BOD_5	17,050	20,860	-
TOC	7,020	8,340	-
Suspended Solids	32,770	14,930	-
Total N	2,144	50	-
NH_3-N	1,500	0	-
Oil and Grease	3,209	610	-
Phenol	793	28	-

All values expressed as #/day, unless otherwise noted. Figures in ( ) signify approximate values.

TABLE 9. WASTEWATER CHARACTERIZATION OF REFINERY AND PETROCHEMICAL EFFLUENTS IN PONCE, PUERTO RICO AREA (MEAN VALUES)(27).

Parameter	Class "C" Refinery		Petrochemical Complex	
	Submerged Outfall	Refinery Effluent	Sea Intake	Main Effluent
Water Temp., °C	28.9	36.1	26.8	32.2
Flow Rate, gpm	1,700	68,100	54,000	54,700
DO	4.7	0.1	5.9	6.0
pH	7.7	7.4	8.1	8.4
Alkalinity	99	123	132	151
Suspended Solids	41	39	37	59
Oil and Grease	1.1	3.9	0.7	1.6
NH_3-N	0.091	1.836	0.030	0.036
Sulfide	1.73	1.00	1.00	1.00
Chloride	21,594	21,089	20,475	19,878
Phenols	0.236	0.961	0.013	0.056
BOD_5	13.3	20.6	1.2	32.9
TOC	5.8	8.4	2.1	14.8

All values in mg/l; Alkalinity (total) expressed as $CaCO_3$; pH - dimensionless.

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RESEARCH & DEVELOPMENT PROJECTS
OF THE
INDUSTRIAL POLLUTION CONTROL SECTION
FOR THE
TEXTILE INDUSTRY

FOR PRESENTATION AT THE

SECOND U. S. - JAPAN CONFERENCE ON SEWAGE TREATMENT TECHNOLOGY

DECEMBER 6, 1972

CHARLES H. RIS

INDUSTRIAL POLLUTION CONTROL SECTION
BRANCH OF APPLIED SCIENCE & TECHNOLOGY
OFFICE OF RESEARCH & MONITORING
U. S. ENVIRONMENTAL PROTECTION AGENCY

SECOND U. S. - JAPAN CONFERENCE

ON

SEWAGE TREATMENT TECHNOLOGY

Technology Development for the Textile Industry

The technology development program for the textile industry is a national program for the research, development and demonstration of new or improved control technology and wastewater management techniques. In-house research and extramural grants and contracts are utilized to fully develop and demonstrate the applicability, effectiveness, reliability and economics of control technology and wastewater management concepts. The program is designed to meet immediate (1977 - Best Practicable) as well as long-range needs (1983 - Best Available) for the development and implementation of pollution control technology with the ultimate goal of zero discharge capability.

The technology development program for the textile industry has been underway since March 1968. To date, the program has five research grants and 15 development and demonstration grants. The total cost of these projects is 5.7 million dollars with EPA providing grant funds of 2.7 million dollars or approximately 48% of project costs.

The attached project information provides a brief description of the more significant textile industry projects that have been implemented. Requests for additional information on any of these projects should be addressed to:

Mr. Charles H. Ris
ORM - Industrial Pollution Control Section
Xerox Building
Washington, D. C. 20460

1. TITLE: State of the Art of Textile Waste Treatment

GRANTEE: Department of Textiles
School of IM & TS
Clemson University
Clemson, South Carolina 29631

TOTAL COST: $31,675 EPA SHARE: $30,007

DESCRIPTION OF PROJECT:

The study will include characterization of the liquid wastes from the major manufacturing processes as to composition and quantity per unit of production, identify successful and unsuccessful treatment processes and disposal practices presently in use, and suggest alternatives for least satisfactory practices. The study will be directed towards identifying areas most in need of research and those areas where research effort is most likely to yield beneficial results.

STATUS: Final Report Available: "State of the Art of Textile Waste Treatment" - 12090ECS - February 1971, from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 - Price $2.50

2. TITLE: A Study of the Photochemical Degradation of Commercial Dyes

GRANTEE: Clemson University
Department of Textiles
Clemson, South Carolina

TOTAL COST: $34,040 EPA SHARE: $31,539

DESCRIPTION OF PROJECT:

The objectives of this twelve month research project are to define and characterize the products of decomposition resulting from ultraviolet radiation of selected commercial textile dyes. The characterization will include distinguishing between photochemical and hydrolytically produced decomposition products.

STATUS: Final report in preparation.

3. TITLE: Water Pollution Reduction Through Recovery of Desizing Wastes

GRANTEE: North Carolina State University
Department of Textile Chemistry
Raleigh, North Carolina 27607

TOTAL COST: $39,688 EPA SHARE: $35,833

DESCRIPTION OF PROJECT:

The objectives of this twelve month research project include the following: to investigate processes for the recovery of desizing wastes in solid or concentrated form suitable for disposal, and to investigate processes for the recovery of desizing wastes in a reusable form. The wastes studied will be those from fabrics sized with carboxymethyl cellulose (CMC), polyvinyl alcohol (PVA), and starch. In addition, data will be collected concerning the biodegradability of the synthetic sizes.

STATUS: Final Report Available: "Water Pollution Reduction Through Recovery of Desizing Wastes," - 12090EOE - February 1972, from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 - Price $0.60

4. TITLE: A Pretreatment Study on Combined Industrial-Municipal Waste Waters

GRANTEE: City of Hagerstown
Maryland

TOTAL COST: $427,853 EPA SHARE: $320,890

DESCRIPTION OF PROJECT:

This project is to evaluate pretreatment techniques for textile dyeing wastes. The dye wastes are reduced sulfur compounds with a high immediate and ultimate oxygen demand that cannot be satisfied in an activated sludge system. The pretreatment technique is to provide initial oxidation by diffused aeration, chlorination, and the separate additions of sodium nitrate and potassium permanganate. Ammoniation will also be used. The project will be for two years and include a waste source investigation, detailed baseline analyses, construction of the pretreatment facilities and full scale paralleling of the treatment system, and evaluation of the pretreatment techniques.

STATUS: Final report in preparation.

5. TITLE: Reuse of Plant Effluent and Cooling Water Blowdown as Process Water

GRANTEE: Fiber Industries, Inc.
Box 10038
Charlotte, North Carolina 28201

TOTAL COST: $500,000 EPA SHARE: $350,000

DESCRIPTION OF PROJECT:

An existing facility provides treatment for the combined sanitary and equalized chemical process wastewaters from a synthetic fiber manufacturing plant. Treatment facilities consist of extended activated sludge aeration basins, clarifier, polishing ponds, aerobic sludge digestion basin, and a sludge holding pond.

The project will evaluate the treatability of this waste in a plastic media trickling filter, the feasibility of algae removal from the polishing pond effluent by use of microscreen filters, the feasibility of BOD, COD, color, odor and taste reduction in the final effluent by use of powered carbon for the purpose of ultimate reuse of the effluent as process makeup water, and chromate reduction of cooling tower blowdown to permit biological treatment.

STATUS: Final Report Available: "Reuse of Chemical Fiber Plant Wastewater and Cooling Water Blowdown" - 12090EUX - October 1970 - Available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 - Price $0.70

6. TITLE: Zinc Precipitation and Recovery Plant

GRANTEE: American Enka Corporation
Enka, North Carolina

TOTAL COST: $980,417 EPA SHARE: $282,700

DESCRIPTION OF PROJECT:

The objective of this twenty month full scale demonstration project is to remove soluble zinc emitted from spin bath operations in the manufacture of viscose rayon. Major activities of the project will include the following:

To direct waste streams containing significant amounts of zinc into the existing 200 gpm chemical precipitation and recovery system, to improve the quality of both zinc sludge produced in the recovery system and the final effluent to enable their reuse in the manufacturing process, to optimize the system, to utilize the technology developed in the design, construction and operation of a new zinc precipitation and recovery system.

STATUS: Final report Available - "Zinc Precipitation and Recovery from Viscose Rayon Wastewater" - 12090ESG - January 1971 - Available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 - Price $1.00

7. TITLE: Demonstration of a New Process for the Treatment of Textile Dyeing and Finishing Waste

GRANTEE: C.H. Masland & Sons
Wakefield, Rhode Island

TOTAL COST: $39,450 EPA SHARE: $27,615

DESCRIPTION OF PROJECT:

The applicant proposes to construct a pilot facility to treat the full flow (50,000 gpd) of process and primary treated sanitary wastes from their Wakefield, Rhode Island plant. The principle operations of the plant are wool and synthetic fiber dyeing and spinning of fibers into yarn. The Pilot Facility will employ a process developed by the Fram Corporation (patent pending) for the biological regeneration of an activated carbon adsorption and filtration system.

The plan of operation provides for (a) effluent profile analysis (b) design, construction, operation, testing, and evaluation of the pilot facility (c) development of design criteria for a 1 to 1.5 mgd plant and (d) preparation of reports.

STATUS: Final Report Available: "Bio-Regenerated Activated Carbon Treatment of Textile Dye Wastewater" - 12090DWM - January 1971 - Available from the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 - Price $1.00

8. TITLE: Demonstration of a New Process for the Treatment of High Pollutant Concentration Textile and Finishing Wastes

GRANTEE: Palisades Industries, Inc.
2 Columbia Street
Peace Dale, Rhode Island 02883

TOTAL COST: $143,750 EPA SHARE: $64,687

DESCRIPTION OF PROJECT:

The project will demonstrate the effectiveness of a pilot scale treatment system which would adequately treat a 50,000 gpd waste flow from a textile dye mill. The system consists of an aerated equalization basin, a anaerobic activated carbon unit, a aerobic activated carbon unit and a activated sludge regeneration unit.

STATUS: Final report in preparation.

9. TITLE: Treatment of Cotton Textile Waste by Enzymes and High Rate Trickling Filter System

GRANTEE: Holliston Mills, Inc.
111 Lenox Street
Norwood, Mass. 02060

TOTAL COST: $285,372 EPA SHARE: $144,741

DESCRIPTION OF PROJECT:

The industry concerned purchases cotton greige goods and produces high grade book bindings. The manufacturing processes which produce a waste flow are desizing, caustic extraction, bleaching, dyeing, and sizing. The applicant proposes to substitute an enzyme desizing chemical in the desizing process which will reduce the pH and BOD load of the waste stream. A treatment system employing a primary clarifier, high rate trickling filter with plastic media, and a secondary clarifier will be used to treat the waste flow. The sludge from the treatment system will then be subjected to an enzyme reaction which will render it amenable to further biological oxidation.

The effectiveness of the manufacturing process change, and the operating characteristics and efficiency of the trickling filter and sludge handling system will be evaluated.

STATUS: Project is operational.

10. TITLE: Biological Oxidation and Chemical Coagulation of Dyestuff and Organic Chemical Wastes

GRANTEE: Southern Dyestuff Company
Division of Martin Marietta Corp.
P. O. Box 10098
Charlotte, North Carolina 28201

TOTAL COST: $1,515,900 EPA SHARE: $501,122

DESCRIPTION OF PROJECT:
The grantee will design, construct, operate, and evaluate a waste treatment system for the control of wastes from a textile dyestuff and organic chemicals plant. The plant produces over 200 different dyestuff products and more than 40 aromatic organic chemicals. The plant will be designed to handle a flow of 2.2 mgd with a BOD of 760 mg/1, a COD of 1750 mg/1, suspended solids of 350 mg/1, and a high color content. The waste treatment system consists of biological decomposition of a thiosulfate waste stream, pH control of acid and alkaline waste streams, and biological oxidation, coagulation and clarification of the combined wastes. The system will be operated for a twelve month period in order to determine the unit process operating parameters and system characteristics.

In addition, pilot-plant studies will be conducted to determine the basic design factors needed to upgrade the system's treatment capabilities for color removal.

STATUS: Project is operational.

11. TITLE: A Study of Gamma Induced Oxidation of Textile Effluents

GRANTEE: American Assoc. of Textile
Chemists and Colorists
P. O. Box 12215
Research Triangle Park, North Carolina

TOTAL COST: $50,000 EPA SHARE: $47,500

DESCRIPTION OF PROJECT:
During the project period, work will be initiated to further develop and optimize a high-pressure, radiolytic oxidation system. The oxidation system is of laboratory-scale size and has initially

been involved in joint FWQA/ORNL (Oak Ridge National Laboratory) experiments. Textile mill wastes, such as dyes, special finishing compounds, and other refractory wastes, will be subjected to the treatment system. Information from the pilot-scale demonstration will be collected concerning optimum operating conditions, radiation dose, temperature, pressure, and cost of treatment for various types and concentrations of waste.

STATUS: Final report in preparation.

12. TITLE: Dyestuff Color Removal by Ionizing Radiation and Chemical Oxidation

GRANTEE: Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

TOTAL COST: $37,685 EPA SHARE: $35,801

DESCRIPTION OF PROJECT:

This twelve month project will investigate the feasibility of a method of treatment dependent on the effects of a combination of ionizing radiation and variety of chemical oxidants on textile dye wastes. The degraded products will be examined with regard to BOD, COD, TOC, color removal, biodegradability, and toxicity to treatment plant biota. A conceptual engineering design will be proposed and a preliminary estimate of treatment costs for a typical dye waste will be made.

STATUS: Final report in preparation.

13. TITLE: Activated Sludge Treatment of Nylon Wastewaters Using Enriched Air

GRANTEE: Beaunit Fibers
Etowah, Tn 37331

TOTAL COST: $338,807 EPA SHARE: $136,927

DESCRIPTION OF PROJECT:

The grantee will design, construct and operate an activated sludge system for the treatment of Nylon 6.6 wastewaters. The activated sludge will be aerated using "off-gases" from the manufacturing process. The off-gases contain 40% available oxygen. The system will be designed for a 150,000 gpd flow with a BOD_5 of 1124 lbs/day. Water Quality Standards require that the system operate with removal efficiencies in excess of 92%.

The treatment system will be operated for a twelve month period during which time raw wastewater characteristics, treatment process parameters and cost of operation will be monitored and evaluated.

STATUS: Project is operational.

14. TITLE: Catalyzed Bio-oxidation and Clarification of Integrated Textile Wastes for Process Water Reuse

GRANTEE: Cone Mills Corporation
Greensboro, North Carolina 27405

TOTAL COST: $115,250 EPA SHARE: $79,415

DESCRIPTION OF PROJECT:

In an effort to satisfy stream water quality standards of 99% BOD_5 reduction, a 99+% nitrogen and phosphate reduction, and a 98% and 96% reduction in COD and suspended solids respectively, the grantee will design, operate and evaluate a pilot scale system to achieve these tertiary levels of treatment. During this 13 month project, three variations of an activated carbon catalyzed bio-oxidation process will be evaluated. The variations involve the use of various coagulant aids.

STATUS: Final report in preparation

15. TITLE: Optimum Treatment of Textile Finishing Wastes - Neutralization and Color Reduction

GRANTEE: Canton Textile Mills
Canton, Georgia 30114

TOTAL COST: $364,511 EPA SHARE: $209,811

DESCRIPTION OF PROJECT:

Canton Textile Mills will demonstrate a system whereby the biological oxidation of textile finishing wastes will be supplemented with flue gas neutralization of the waste stream for control of pH, and fly ash adsorption for the control of color. The pretreatment and tertiary treatment processes will augment an optimized biological oxidation system capable of producing an effluent of 30 mg/1 BOD & SS. The entire waste treatment system will be designed to treat a 550,000 gallon per day waste flow and will be operated for a 12 month period during which time operating characteristics will be documented and evaluated.

STATUS: Project is operational.

16. TITLE: Recovery and Reuse of Synthetic Size from Textile Finishing Wastewaters

GRANTEE: Department of Textile Chemistry
North Carolina State University
Raleigh, North Carolina 27607

TOTAL COST: $72,771 EPA SHARE: $48,043

DESCRIPTION OF PROJECT:
The objective of this twelve month project is to demonstrate in pilot scale, a process for the removal and recovery of carboxymethyl cellulose size from textile finishing wastewaters. Previous studies under EPA Grant Project 12090 EOE have identified the technical and economic feasibility of removing, recovering and reusing the CMC size. The size will be removed from dilute concentrations by chemical precipitation using alum. Reuse tests will be conducted to further evaluate and demonstrate the reuse potential of the recovered material. A final report will be prepared concerning all aspects of the project.

STATUS: Project is operational.

17. TITLE: Activated Sludge and Alum Precipitation of Textile Dye and Finishing Wastewaters

GRANTEE: Blue Ridge-Winkler Textiles
Bangor, Pennsylvania 18013

TOTAL COST: $264,615 EPA SHARE: $96,156

DESCRIPTION OF PROJECT:
This 15 month project will demonstrate in full scale the operation of a newly constructed 750,000 gpd wastewater treatment facility for the treatment of textile dyeing and finishing wastewaters. The wastewaters originate from the dyeing and finishing of synthetic and blend yarns and exhibit high organic color content. The treatment system includes the following processes:

equalization; nutrient and pH control; activated sludge including secondary sedimentation; alum coagulation consisting of rapid mixing, flocculation and final clarification; chlorination; and sludge dewatering. Preliminary plant operating data shows a potential for 95% reduction in BOD and a 90% reduction in color contaminants. The data collected will be sufficient to characterize the raw wastewater, to determine the operating characteristics of the unit processes (especially with respect to extent of color removal), to fully establish the system treatment capabilities, and to determine the cost of treatment under a variety of conditions.

STATUS: Project is operational.

18. TITLE: Treatment and Reuse of Textile DyeHouse Wastewaters Using Reverse Osmosis

GRANTEE: LaFrance Industries
LaFrance, South Carolina 29631

TOTAL COST: $293,350 EPA SHARE: $198,812

DESCRIPTION OF PROJECT:

This 20 month project will demonstrate in pilot scale the technical feasibility of employing membrane technology for the treatment and control of textile dyehouse wastewaters. Pilot scale reverse osmosis units will evaluate the use of cellulose acetate and dynamic membrane systems for the separation of dissolved solids and color concentrates. The resulting retentate and permeate from the membrane units will be evaluated for recycle and reuse potential in the dyeing processes.

STATUS: Project is operational.

19. TITLE: Grease Removal and Pilot-Scale Biological Oxidation of Wool Scouring Wastewaters

GRANTEE: Division of Water Pollution Control
Commonwealth of Massachusetts
100 Cambridge Street
Boston, Massachusetts 02202

TOTAL COST: $162,000 EPA SHARE: $98,482

DESCRIPTION OF PROJECT:

The State of Massachusetts will direct a project to demonstrate in pilot scale the feasibility of modifying a grease removal system and employing an optimized extended aeration system for the removal of organic contaminants from wool-scouring wastewaters. The Barre Wool Combing Company in South Barre, Massachusetts, has a wool-scouring wastewater flow of 290,000 gallons per day which is very high in grease, suspended solids, and biochemical oxygen demand. The pilot-scale treatment system will be operated at a 1000-gpd rate for a 7-month period to allow for evaluation of the treatment processes through the winter months.

STATUS: Project is operational.

THE EPA RESEARCH AND DEVELOPMENT PROGRAM FOR WASTEWATER MANAGEMENT IN THE FOOD PROCESSING INDUSTRY

by Gilbert S. Jackson, Ph.D. (Program Coordinator), and H. G. Keeler, Chief, EPA Food, Paper and other Industrial Sources.

Introduction

As an introduction it would be appropriate to quote President Richard M. Nixon who stated "we can no longer afford the indiscriminate waste of our natural resources; neither should be accept as inevitable the mounting costs of waste removal. We must move increasingly towards closed systems that recycle what are now considered wastes back into useful and productive purposes".

As a way of further introduction, I would like to go over some background on the Japanese agricultural industry so we would have some ideas in areas of mutual interest.

Most of the information to be presented was obtained from the Japan Yearbook (1971). To begin with twenty-three percent of your people are involved in agriculture as compared to six percent of the United States population. You have very efficient methods of farming, as only sixteen percent of your total land area is fertile enough to be utilized.

The greatest rainfall in your country occurs in the south and west, producing two crops of paddy rice and wheat. The north and eastern sectors are extremely cold and not very fertile, being mainly comprised of porous acidic lava formations. You use "night soil" and other organic fertilizers intensively. In addition, there is a shortage of calcium so a massive lime addition is needed to replenish your depleted soil.

By the mid twentieth century, Japan had used the highest amount of fertilizer per acre except for the Netherlands in regard to your main staples, as fish and seafood, you are one of the leading fishery nations with over fifty percent of the world's volume.

Recently by careful and intensive cultivation on two or two and a half acre farm units you have achieved an increase in meat and dairy production. Furthermore, a rapid expansion of farm machinery production has enabled Japan to become self-sufficient in rice production with a subsequent decrease in agricultural workers.

Your whaling industry is one of the largest in the world. In addition, your seafood industry has captured 6.8 million tons of fish annually including herring, tuna, prawns, eels, cuttlefish and is supplemented by a large in-land fishing fleet.

In 1971 Japan's leading food products and tonnage were:

Commodity	Tonnage
Processed Meats	229,000
Beet Sugar	344,000
Rice	12,528,000
Wheat	474,000
Sugar Cane	759,000
Tomatoes	787,000
Canteloupe	274,000
Salt	950,806

Some examples of wastewater projects in the food processing industry that have been supported by EPA and could benefit the Japanese agricultural industry are given in this report.

I. Water Pollution Legislation

On July 9, 1970, President Nixon sent to Congress a reorganization plan removing 15 units from existing departments and agencies, and relocating them into a new independent Agency. These plans became effective on December 2, 1970 establishing the U.S. Environmental Protection Agency.

EPA brings under one organizational roof Federal activities in controlling air and water pollution, drinking water quality, solid wastes, pesticides, environmental radiation and noise. It is an independent regulatory agency that has no obligation to promote agriculture. commerce or industry. In general, the agency is responsible for conducting research and demonstrations, for establishing and enforcing standards, for monitoring pollution in the environment, and perhaps most important, for assisting State and local governments in their own efforts. The purpose is to mount an integrated attack on pollution and at the same time, to make orderly progress toward understanding the environment as a single system of independent, but interrelated parts.

A. Legislative Background

Federal water legislation dates back to the nineteenth century, when Congress enacted the River and Harbor Act of 1886, recodified in the Rivers and Harbor Act of 1899. It is only within the last seven years, however, that major water pollution legislation has been passed.

Recognizing the threat that dirty water posed to the public health and welfare, Congress enacted the Federal Water Pollution Control Act (FWPCA), in order to "enhance the quality and value of our water resources and to establish a national policy for the prevention, control and abatement of water pollution." FWPCA and its several amendments set out the basic legal authority for Federal regulation of water quality.

The original Act was passed in 1948. Its amendments broadened the Federal government's authority in water pollution control. The Water Pollution Control Act of 1956 strengthened enforcement provisions by providing for an abatement suit at the request of a State pollution control agency; where health was being endangered, the Federal government no longer had to receive the consent of all States involved. The Federal role was further expanded under the Water Quality Act of 1965. That act provided for the setting of water quality standards which are State and Federally enforceable; it became the basis for interstate water quality standards. The Clean Water Restoration Act of 1966 imposed a $100 per day fine on polluters who failed to submit a required report. The Water Quality Improvement Act of 1970, again expanded Federal authority, and established State certification procedure to prevent degradation of water below applicable standards.

Despite the improvements achieved by each amendment to the original Act, the result of this sporadic legislation was a hodgepodge of law. Eleven reorganizations and restructurings of Federal agency responsibility compounded the difficulty of effectively implementing the law. To solve these problems, the 1972 amendments to the FWPCA restructured the authority for water pollution control and consolidated authority in the Administrator of the Environmental Protection Agency.

B. The Research and Demonstration Program

The Clean Water Restoration Act and its amendments provided not only increased authorization for Federal grants for construction of sewage plants, but also for research and demonstration of new or improved methods for municipal and industrial water pollution control.

Under provisions of this Act, the EPA has developed a research and development program for water pollution control from industrial sources. This discussion of the Federal program will hopefully indicate areas of mutual participation and cooperation, by and between the Federal, state, municipal and industrial communities.

The Federal program is unusual--perhaps unique in Government. It is a Research, Development and Demonstration program. It is a coordinated, problem-solving program which is dedicated to exploratory research of new and imaginative pollution control methods. It is a program which provides for the engineering development of these methods to solve the practical problems associated with bringing an "idea" out of the laboratory and into the real world. Finally it allows for the demonstration of this new technology to go that extra, normally neglected, step of showing the decision-makers that new and improved technology has really arrived and may be implemented.

In-house research and development activities, in conjunction with extramural research contracts, and grants are utilized to fully develop and demonstrate the applicability, effectiveness, reliability and economics of control and/or treatment techniques for abating pollution from industry. The program is designed to meet immediate as well as long-range needs. The needs are for application and evaluation of pollution control techniques, devices, water reuse systems, and systems for ultimate disposal of industrial and joint municipal-industrial wastes.

The program is unique, since, for the first time, industry may participate in grant programs to develop and demonstrate new or improved methods of treating industrial wastes or otherwise preventing pollution, which method shall have industry-wide application. Grants so authorized may not exceed 70% of the project cost, and are limited to a maximum of $1 million.

The Federal Water Pollution Control Act, as amended, also provided grants for projects which can develop and demonstrate "new or improved methods of jointly treating municipal and industrial wastes." Capital advantages are obviously possible in many cases if industries can discharge their wastes into municipal systems. Accordingly, the grants program represents a truly cooperative effort; it is a cost-sharing type of contract.

Obviously with these tools the EPA can support almost any related worthwhile project under almost any type of institutional arrangement. We have the means for sponsoring research, assisting pilot-scale developments, and for participating in large (full-scale) demonstration projects. To receive a grant several conditions must be met. The project must have technical merit. There must be technical competence associated with the project, either as provided by the grantee himself or by consultants which he employs. Finally the project must fulfill an identified need. This means it must usefully demonstrate a way to combat water pollution. The results obtained must be accurate with respect to costs and performance, and they must be made available to the public.

II. Wastewater Management - The Food Industry

Let us define wastes, for the moment, as unusuable "misplaced resources" of human activities. We say "for the moment," because each waste has usage in some time frame and is some "eco-system". This time frame is impacted by modern Technology and need. We say "unusuable" because man does not willingly throw away his assets if it is to his advantage to use a particular material. Time, need, place, and technology all determine the scope of a particular industrial problem. Yesterday's moldy bread becomes today's penicillin. Last month's food processing wastes could be in tommorrows medicines, synthetic textiles, dyes, and polishing compounds.

We all recognize that industrial wastes then could be developed into economically and technically sound by-product recovery systems or water reuse schemes. Based upon estimates of the "average" quantity of pollutant produced per manufactured product unit, the indications are that the metals, chemical, paper, petroleum, and food industries contribute about 90% of the BODs in industrial wastewaters before treatment. (1)"The Cost of Clean Waters" Vol 1., Summary June 10, 1968, U.S. Department of Interior.

The food processing industry represents about 20% of this pollutional load in the United States. Moreover, the rate of industrial production which correlates closely with the load of industrial wastes generated is increasing at the rate of 4.5% a year or more than three times faster than the populated growth.

Add to this the extensive complexities of composition of industrial wastes and the realization immediately becomes apparent that the solutions to industrial water pollution control is not a simple one.

Due to "economy of scale," larger industrial plants can often treat their wastes more economically than smaller plants of the same type. Moreover, the same treatment technology may not be economical for the treatment of wastes produced in similar but smaller plants. At present, it is relatively common for small plants to discharge their wastes to the community sewer system and to depend upon the municipal sewage plant for the treatment. But many plants do not have sewer systems readily available. Furthermore, appropriate joint treatment systems for some industrial wastes have not been developed. It is, thus, imperative that better methods for the treatment or control of industrial wastes be developed with special recognition that:

1. Many municipal sewage plants are overloaded and sensitive to strong and toxic industrial wastes and may be forced to restrict the types and volumes of industrial wastes discharged without pretreatment to the municipal system.

2. Certain industrial wastes should increasingly be considered as undeveloped national resources since many industrial wastes contain valuable by-products.

3. Be a technique which would permit the recycling of recovered materials, including renovated water, back to the production operation or to other use.

4. Be simple, reliable, and require minimum operating labor.

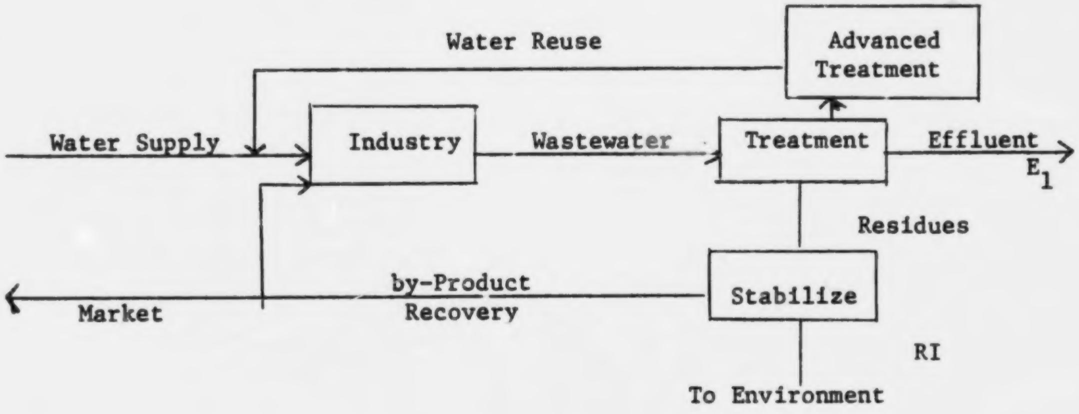
5. Require relatively low capital investment.

The Food and Kindred Products area is part of the overall EPA Industrial Pollution Control Program. Activities under this subprogram element encompass those industries dealing with the processing of products for Human or Animal Consumption.

First of all our program has found, particularly for the smaller processors, that reduction of wastes can be achieved efficiently and economically by process modifications and improved housekeeping. This is borne out generally by the fact that quantities of water consumption per product unit has been decreasing in most industries as a result of increasing water usage efficiency by recycling treated wastewater or by multiple usage of water. Modern technological innovations, practices, and designs increasingly stress waste control by these methods of efficient water usage. Gentlemen, please do not overlook what good housekeeping can do for your industry.

In general the schematic depicted below indicates the various directions as industrial process can go to obtain the goals of developing and demonstrating industrial water reuse and product (or by-product) recovery methods which are economically sound.

ALTERNATIVES FOR INDUSTRIAL WATER POLLUTION CONTROL



Gentlemen, remember that the waste viewed on the diagram should be regarded as part of the overall processing operation and the treatment costs must then be included in the final product pricing. Waste disposal operations, even landfill, normally results in a net cost to the industry producing the waste. This cost can be offset by employment of by-product recovery and utilization techniques that reduce the net treatment cost and recycle useful products back into the ecosystem. In addition, due to the great seasonality of some food processing industry a pollutional load on the local municipal systems would be removed during the processing operations.

It should be remembered that wastewater treatment for recovery and reuse, by-product recovery of waste materials for beneficial purposes and recycle are all important aspects to achieving the final goal of a "closed industrial system".

A partial listing of some of the projects employing the aforementioned techniques to great success even profitability and partially supported by EPA are located in the next table.

These cooperative ventures with EPA have given rise to a new industrial "Environmental Awareness". This has come about due to the public outcry and legislative mandates at both a federal and state level. The food industry is dependent upon our nation's rivers and streams for suitable water to continue processing. Closed cycle operations may be economically competitive with treatment costs.

EPA INDUSTRIAL WATER REUSE AND/OR BY-PRODUCT RECOVERY PROJECTS

Industry[a]

CHEMICAL
- Dow Chemical
- Mineral Pigments Co.
- State of Florida
- State of Louisiana
- Farmers Chemical Assoc.

METALS
- Beaton and Corbin Mfg. Co.
- Interlake Steel Corp.
- S.K. Williams
- Volco Brass and Copper

PETROLEUM
- BP Oil

PULP AND PAPER
- Georgia - Kraft Co.
- Green Bay Pkg. Co.
- International Paper Co.
- Pulp Mfg. Research Inst.
- S. D. Warren Co.
- St. Regis Paper Co.
- Weyerhauser Co.

Industry[a]

FOOD
- Amber Laboratories
- Archer Daniels Midland Co.
- Anheuser-Busch Inc.
- Beefland Int. Inc.
- Beet Sugar Dev. Foundation
- Central Soya
- Crowley's Milk Co., Inc.
- Green Giant Co.
- Maryland Dept. of Health
- National Canners Assoc.
- North Star R&D Inst.
- State of Vermont
- Winter Garden Citrus Prod. Coop.
- Dairy Research and Dev.
- Pacific Egg and Poultry Assoc.

TEXTILES
- American Enka Corp.
- Fiber Ind.

OTHER
- Leather goods
  - Blueside Tanning Co.
  - S. B. Foote
- Water Supply
  - Gainesville, Fla.

STONE, CLAY, GLASS
- Johns-Manville Prod. Corp.
- State of Vermont

[a] Industries listed are involved in projects on closed-loop systems water reuse, or product recovery.

As a supplement to this talk and to depict graphically some areas of possible interest by your government in the food processing area, we will show some selected slides from our projects:

The first project discussed is with the Kent Cheese Company in Melrose Park, Illinois awarded July 1, 1969 and completed in April, 1972. The EPA share was $46,000 out of a total of $65,000. This project, demonstrates the effectiveness of aerated lagoons for the treatment of cheese whey process rinse water. The treatment system utilizes two aerobic lagoons in series with submerged mechanical aeration equipment producing an extended aeration process. Data was collected to evaluate the extented aeration process on the aforementioned cheese whey wastewater streams.

The next series of slides and project concerns the aerobic treatment of fruit processing wastes awarded to the Snokist growers, Yakima, Washington awarded August 1967 and completed March 1970. EPA award share was $347,669 out of total $572,252. The project studied two stages of a treatment scheme. The initial wastewater management scheme used an aerated lagoon, whereas the second stage required additional aeration and clarification. This treatment system removed nearly 99% of the BOD and COD.

The treatment systems were studied over the two operating seasons, and operated as an aerated lagoon, as an activated sludge treatment system and as activated sludge system but including reaeration. Data was collected on biological substrate assimilation, sludge growth, oxygen uptake and sludge settleability. Constants were obtained from this data. Success of the treatment system is described in the final report on the project and the costs of treatment computed. It is recommended that aerated lagoon treatment be used where 70 percent removal of BOD is desired and suspended solids are permissible in the effluent. Activated sludge treatment is recommended for greater than 90 percent BOD removal and where effluent suspended solids must be minimized.

The next project comprised the tertiary treatment of combined municipal and industrial wastes. In this case with the City of Tualatin, Oregon awarded for $173,100 out of a total cost of $230,800. This sytem had an industrial waste, generated by the manufacture of dog food, comprising 25% of the total BOD_5 loading.

The tertiary operation consisted of flocculation, settling, and filtration with alum addition for removal of phosphates.

Another demonstration project along similar lines of combined treatment is located at the City of Dallas, Oregon. In this case, EPA awarded $325,000 out of a total cost of $463,000. The industrial waste in this case was highly seasonal and emanated from nearby fruit and vegetable canneries. The complete aerobic secondary treatment facility was designed for an average daily flow of 2.0 mgl and a BOD load of 7000 lbs. per day.

The results of this study indicate the flexibility and economy of the completely aerobic system, consisting of activated sludge with aerobic digestion, for a small community with proportionately high industrial wastewater loads. The effluent BOD concentration averaged 8 mg/l and the effluent total suspended solids concentration averaged 13 mg/l for the 15-month study period. The biological solids yield averaged about 0.7 pounds of solids per pound of BOD removed and the net accumulation of biological volatile solids was about 0.42 pounds of volatile solids per pound of BOD removed. These values were obtained with a MLSS concentration range of 700 to 3000 mg/l, an average sludge age of 19 days and an organic loading range of 0.05 to 0.40 pounds of BOD per pound of MLSS per day. Total capital cost of the system was about 66 percent of that for a conventional activated sludge plant and operation and maintenance costs were only about 33 percent of those for a conventional system.

By-Product Recovery

In the area of by-product recovery several projects will be discussed.

The first of these involved the development and demonstration of an ultrafiltration plant for the abatement of pollution from cottage cheese whey. This is with Crowley's Milk Col, Binghamton, New York. The EPA contribution amounted to close to a half-million dollars towards a total pilot phase and demonstration phase cost of $914,000.

A two-stage ultrafiltration system for the separation and concentration of protein and lactose or straight acid whey concentration with a resulting influent BOD reduction of 99 percent was demonstrated. Phase I lasted 13 months and called for the design, detailed engineering, construction, operation and evaluation in Binghamton, New York of a 10,000 lb/day UF system. This also included the design of a 250,000 lb/day system for full-scale demonstration under Phase II. Duration of Phase II was 17 months, and proved highly successful using the guidance and expertise of Abcor Inc., who supplied the membrane technology to this project.

Another project that EPA is funding consists of the study of Protein Production from Acid Whey via fermentation. This was investigated at Amber Laboratories, Juneau, Wisconsin.

The objective of this 10 month project was to demonstrate an efficient acid whey fermentation process to recover protein by-products. The fermentation process converted whole and deproteinized acid whey, in a 500 gallon/day batch reactor, to a feed product using Saccharomyces fragilis.

The fermentation was accomplished by the usage of a closed vessel, and deep tank fermentors to keep odors and vapors at a minimum. All process streams were investigated for pollutional effects. Feed recovery systems will have a zero discharge and investigation dealing with development of human grade material will ascertain means of achieving 30 ppm BOD_5 in the final effluent.

This project has now successfully completed the pilot phase, with remarkable results and is beginning to tool up for the full-scale prototype of protein recovery system.

Another project which we are quite proud of concerns an effort by EPA, the State of Hawaii, and C. Brewer's Sons Ltd. in the cane sugar area to develop a pilot plant incorporating an ecostatic can processing system.

The objective of this project is to develop on a pilot scale, an economical system which will eliminate liquid-borne wastes from sugar cane processing plants. This system will incorporate a harvest cleaner system, a dry cleaner soil remover, a juice wet cleaner, a trash dry cleaner, a recycled water cleaner, and a stabilized slope disposal system. All fibrous solid wastes including leaf and bagasse will ultimately be used in low emission boilers for electric power generation.

This has proved so successful that most of the plant's electric power now originates from bagasse that had heretofore been discharged or discarded.

Process Modifications

Our program involves itself in process modifications and unit process alterations from an ecological standpoint. This would involve helping the processor build a prototype to demonstrate how a novel system uses less water in a unit operation and yet is as functional as its replacement unit.

This was true in the development by the (U.S.) Department of Agriculture Western Regional Laboratory of the dry caustic peeler which was demonstreated at Western Potato Service, Inc., Grand Forks, North Dakota. The objective of this grant was to demonstrate at full scale the economics and pollution reduction characteristics of a potato "dry" caustic peeling system and to use as a base for comparison data to be obtained from a similar facility employing the conventional "wet" caustic peeling operation.

Dry Caustic Peeler

A further area of application was in the dry caustic peeling of tree fruit, reducing liquid waste and BODs strength. This was demonstrated under the auspices of the National Canners Association and Del Monte Corp. at a large peach cannery in the State of California. The description of each grant follows:

National Canners Association

The National Canners Association, in cooperation with the U.S. Department of Agriculture, will install demonstration-scale equipment in a fruit cannery. The basic project objectives are to demonstrate the feasibility of using the dry caustic peeling process in the processing of tree fruit. Operational data will be collected during the grant period which will allow the comparison of the yield and quality of the peeled fruit and the quantity and quality of the process wastes with the conventional peeling process.

Del Monte Corporation

During the 9-month project period, Del Monte Corporation will design, construct, install, and operate a 15 ton per hour "dry caustic" unit on a clingstone peach line at Plant No. 3. Evaluation of this unit will provide a full-scale comparison with conventional peeling operations and substantiate earlier results obtained under project 12060 FQE. Previous data indicates water reduction from 530 to 35 gallons per ton of peaches processed is possible, as well as reducing COD and suspended solids in the liquid waste from 60 to 18 lbs/ton and 10 to 3 lbs/ton respectively.

This dry caustic peeling principle, we are happy to announce, has saved millions of gallons of fresh water without sacrificing any industrial practices from the standpoint of both economics and efficiency. We are quite proud of this accomplishment. This procedure is now being adapted by the canning industries as established state-of-the-art.

Hot Gas Blanching

A step in the processing of vegetables for canning that was most troublesome for us in terms of the BODs content is the blanching operation. This operation incorporates huge amounts of heat energy and water to essentially eliminate or deactivate enzymes from the vegetables. Therefore, we (EPA) searched for alternative blanching procedures that could accomplish the unit operator at a low water volume.

Three studies were then funded by this program. The first study, with the National Canners Association; essentially initially analyzed four blanching systems placed at various canneries. These included steam, hot water, micro-wave, and hot air.

The primary objective is to demonstrate the technical and economic feasibility of the hot air blanching process in the vegetable preserving industry for reducing a major source of pollution. During the 12 month period, continuous hot air blanching runs will be conducted at two vegetable processing facilities: Stockton, California and Salem, Oregon on five vegetable commodities (spinach, green peas, corn, green beans, and beets). A minimum of 3-8 hours continuous blanching runs per vegetable commodity will be conducted after preliminary short runs to determine optimum process variables. Process variables will be recorded in order to calculate operating costs. Steam condensate will be measured and waste water characteristics (BOD_5, COD, pH, SS) determined. Product quality will be evauated and compared with conventionally blanched product by analysis of vitamin and mineral content, and consumer taste evaluations.

Individual Quick Blanch

In keeping up the spirit of technological enlightenment we are funding an alternative method of blanching developed at the University of Wisconsin entitled the "Individual Quick Blanch" system. This is also an on-going grant study as the aforementioned hot gas blancher.

This grant project will study and evaluate a new low water volume blanching process in the canning of vegetables called the individual Quick Blanch (1GB). A pilot scale 1QB unit will be installed at the University of Wisconsin's Department of Food Science Laboratory which is located near several commercial vegetable canners.

Several varieties of vegetables, including different species of the same vegetables, will be blanced using 1QB and commercial type steam and hot water blanching systems. Blancher effluent volume and various water quality parameters will be analyzed for the three blanching modes.

Quality of the blanched commodities will be evaluated after storage by objective and subjective tests. Design recommendations for a full-scale IGB unit will result if process expectations are fulfilled.

It should be added that extensive nutrition testing, vitamin analysis and trained taste panel evaluations are done on the final products of any experimental wastewater management scheme or process modification.

We should point out that in the future this program will be funded at about the same level and the primary emphasis will be upon tertiary systems or even "closing the loop" to effect zero pollutional discharge thus effectively eliminating all water-borne food processing wastes.

You map keep abreast of our activities through the annual Food Waste Symposium (the latest in Syracuse, New York, March 26-28, 1973) or through the current "Projects of the Industrial Pollution Control Branch" Book which lists capsule accounts of the aforementioned projects.

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